

**An Addition and Remodel**  
**FOR THE**  
**TELLER COUNTY**  
**SHERIFF'S OFFICE**  
**DIVIDE, COLORADO**

*Construction Documents - 09/16/2019*

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**PROJECT MANUAL**  
VOLUME 2 OF 2

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**KEYSTONE ASSOCIATES INC.**  
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Colorado Springs, Colorado 80907

**Project No. 1820**



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**SECTION 21 0000**  
**WET-PIPE AUTOMATIC FIRE SUPPRESSION SYSTEMS**

**PART 1 - GENERAL**

**1.0 RELATED DOCUMENTS**

Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification sections, apply to the work specified in this Section.

**1.1 DESCRIPTION OF WORK**

- A. Scope: Provide a complete wet-pipe sprinkler and Class I standpipe system and associated equipment, ready for operation. Contractor shall obtain all required permits and shall perform all testing required by local and State authorities.
- B. Description of Work: The work includes the design and installation of an automatic wet-pipe fire sprinkler system.
- C. Authority Having Jurisdiction: Any reference in the specifications or applicable codes to the "Authority Having Jurisdiction" shall be interpreted to mean the local fire department.

**1.2 QUALITY ASSURANCE**

- A. Qualifications of Installer: Prior to installation, if required, submit data showing that the Contractor has successfully installed automatic wet pipe fire sprinkler systems of at least 200 sprinkler heads each. The data shall include the names and locations of at least two installations where the Contractor, or the subcontractor referred to above, has installed such systems.
  - 1. Design (including hydraulic calculations) shall be by a NICET Level IV Senior Engineering Technician (in automatic sprinkler system design) or a Professional Engineer (P.E.), licensed in Fire Protection Engineering.
  - 2. Service Organization: The Contractor shall furnish evidence that there is an experienced and effective service organization which carries a stock of repair parts for the system in order to readily effect repairs throughout the warranty period. Should the Contractor fail to comply with the service requirements of this section, the Owner will then have the option to make the necessary repairs and back charge the Contractor without any loss of warranty or guarantee as provided by the contract documents.
- B. Applicable Publications: The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only. All publications listed below refer to the most current edition.
  - 1. American Society for Testing and Materials (ASTM) Publications:

- A53 Pipe, Steel, Black and Hot Dipped, Zinc-Coated, Welded and Seamless
- A135 Welded and Seamless Steel Pipe

2. National Fire Protection Association (NFPA) Publications:

- 13 Installation of Sprinkler Systems
- 14 Installation of Standpipe and Hose Systems
- 20 Centrifugal Fire Pumps
- 70 National Electrical Code
- 72 National Fire Alarm Code

- 3. Uniform Building Code and the Uniform Fire Code (1997)
- 4. Underwriters Laboratories, Inc. (UL) Publications:

Fire Protection Equipment Directory

1.3 SYSTEM DESIGN

- A. The design shall conform to NFPA 13 and 14 and the requirements shown on the contract documents including pipe sizing and as specified herein. Design of the automatic wet pipe sprinkler system shall be for Light Hazard Occupancy, 0.10 GPM over 900 sq. ft. with simulating 2 heads flowing from each outlet for future tenant areas and Ordinary Gr. I Hazard Occupancy, 0.15 GPM over 1500 sq. ft. area for mechanical rooms and utility areas. The design, equipment, materials, installation, workmanship, examination, inspection and testing shall be in strict accordance with NFPA 13, except as modified herein. The system shall include all materials, accessories, and equipment inside and outside the building to provide and maintain a system complete and ready for use. Design and provide each system giving full consideration to blind spaces, piping, electrical equipment, ductwork and other construction and equipment in accordance with detailed drawings to be submitted for approval. Equipment for fire protection service shall be UL listed or FM approved for use in wet pipe sprinkler systems. In the NFPA publications referred to herein, the advisory provisions shall be considered mandatory, as though the word "shall" had been substituted for "should," wherever it appears.
- B. Water Distribution: Distribution shall be uniform throughout the area which it is assumed the sprinkler heads will open. Variation in discharge from individual heads in the hydraulically most remote area shall be between 100 and 120 percent of the specified density.
- C. Clearance From Electrical Equipment: Piping and automatic sprinklers are prohibited directly over:
  - 1. Transformers.
  - 2. Switchboards.
  - 3. Motor control centers.
  - 4. Electrical panels.

If installing pipe over electrical equipment is unavoidable, provide water shields under piping to protect electrical equipment. The AHJ shall be consulted when

the use of water shields is proposed.

- D. Location of Sprinkler Heads: Heads in relation to the ceiling and the spacing of sprinkler heads shall not exceed their listed area of coverage. Uniformly space sprinklers on the branch piping. Locate sprinkler heads in a consistent pattern with ceiling grid, lights, and supply air diffusers.
- E. Sprinkler Discharge Area: The sprinkler discharge area shall be the hydraulically most remote and demanding area as defined in NFPA 13.
- F. Hose Allowances: Per NFPA 13 & 14.
- G. Hydraulic Calculations: Any required hydraulic calculations shall be in conformance with NFPA 13 and NFPA 14.
  - 1. Margin of Safety: The sprinkler system shall be hydraulically designed so that the total water flow and pressure demand is at least 15% less than the available water flow and pressure at the site. The water supply information used shall be as shown on the Contract Documents.
  - 2. Friction Losses: Calculate losses in piping in accordance with the Hazen-Williams formula with "C" value of 100 for unlined ductile iron piping, 120 for steel piping, 140 for cement-lined ductile-iron piping, 150 for copper tubing and plastic piping.
  - 3. Flow Velocity: Piping shall be sized so that the water flow velocity does not exceed 32 fps at any point in the system during maximum water flow (including inside hose demand). Flow velocity in each pipe segment is to be provided in the calculations.
  - 4. Test Point: Calculations shall be brought back to the flow test point including all elevation changes or a net elevation change provision.
  - 3. Area of Coverage and Density: The area of coverage and density for each sprinkler shall be provided in the calculations.
  - 4. Equivalent Lengths: The equivalent lengths for all types of fitting and valve used shall be provided.
  - 5. Supply and Demand Graph(s): A graph comparing the water supply and the sprinkler and hose stream demand for each remote area shall be provided. Pressure and flow values for the supply and demand curves are to be provided on N<sup>1.85</sup> graph paper or equivalent computer generated print out.

#### 1.4 SUBMITTALS

Partial submittals will not be acceptable. Before any work is commenced, submit manufacturer's data (with listing or approval), system calculations, and complete sets of working drawings as approved by local fire department.

- A. Manufacturers' Data: Annotate descriptive data to show the specific model, type and size of each item the Contractor proposes to furnish. Include data for proper installation of each system including (as applicable):
  - 1. Pipe and fittings.
  - 2. Valves.
  - 3. Exterior horn and strobe.

4. Sprinkler heads.
  5. Pipe hangers and supports.
  6. Pressure and waterflow switches.
  7. Tamper switches.
  8. Inspector's test connection.
  9. Cabinet.
  10. Fire department connections.
  11. Hose valves.
  12. Backflow preventer.
  13. Roof manifold/test header.
- B. Shop Drawings: Prepare working drawings on sheets not smaller than 24 inches by 36 inches in accordance with the requirements for "Working Plans" as specified in NFPA 13. A scaled site plan, with the location and elevation of the water flow test, shall be provided on the drawings. Drawings are to include isometric diagram of sprinkler riser and feed mains, including all control valves.
- C. As-built (Record) Working Drawings: After completion, but before final acceptance of the work, furnish a complete set of as-built drawings for review and approval by Engineer. Make all necessary corrections to the drawings and furnish two sets of as-built drawings for record purposes. The drawings shall not be smaller than 24 inches x 36 inches on reproducible sepia with title block similar to full size contract documents.
- D. Operation and Maintenance Manuals: Furnish two (2) instruction manuals containing complete operation and maintenance instructions for components of the complete system, including the specific make and model of all valves, water flow and tamper switches, backflow preventers, booster pump and accessories, and other trim furnished. Serial numbers and ordering information shall be provided. Place one copy of instruction manual in a flexible, oil-resistant protective binder and mount in an accessible location in the vicinity of each control valve or piece of equipment. Furnish one additional copy of the instruction manual to the Owner.

## PART 2 - PRODUCTS

### 2.1 ABOVE GROUND PIPING SYSTEMS

- A. Provide fittings for changes in direction of piping and for all connections. Arrange piping so that it can be drained at the main riser. Make changes in piping sizes through standard tapered, reducing pipe fittings; the use of bushings will not be permitted except as noted on the contract documents for future tenant improvement provisions. Perform welding in the shop; field welding will not be permitted. Run piping concealed in areas with suspended ceilings, except as noted on the Drawings.
- B. Sprinkler Pipe and Fittings: Provide in accordance with NFPA 13. Schedule 5 pipe and its equivalent shall not be used in any part of these systems.
- C. Use of restriction orifices, reducing flanges, unions, and plain-end fittings will not be permitted.



- D. Pipe Hangers and Supports: Provide in accordance with NFPA 13.
- E. Identification Signs: Attach properly lettered approved metal or polycarbonate signs conforming to NFPA 13 to each valve and alarm device. Polycarbonate signs shall be red with engraved white letters. Signs at valves shall describe the sprinkler zone it controls and state that the valve is to remain open. Permanently affix design data nameplate to the riser of each system.
- F. Inspector's Test Connection: Provide test connections no higher than 5 feet above the floor at the hydraulically most remote part of each system (piped to exterior). Provide combination drain valve and test connection. Drainage and test valves shall be bronze globe, angle, or gate valves.
- G. Drains: Provide drain piping to discharge at safe points outside the building. Provide auxiliary drains as required by NFPA 13. Splash guards are to be provided where necessary at discharge outlets.
- H. Pipe Sleeves and Seals: Provide where conduit or piping passes through walls, floors, roofs and partitions. Provide clearance between exterior of piping and interior of sleeve in accordance with NFPA 13. Secure sleeves in proper position and location during construction. Provide sleeves of sufficient length to pass through the entire thickness of walls, floors, roofs, and partitions. All penetrations shall be properly sealed and fire stopped to maintain room integrity and any wall/floor/ceiling fire resistance ratings. See Section 07270 Firestopping.
  - 1. Sleeves in Masonry and Concrete Walls, Floors, and Roofs: Provide ASTM A53, Schedule 40, zinc-coated steel pipe sleeves. Sleeves in floors shall project 4 inches above finished floors to prevent seepage.
  - 2. Sleeves in Partitions and Other than Masonry and Concrete Walls, Floors and Roofs: Sleeves shall be constructed from either zinc-coated schedule 40 steel pipe or zinc-coated 26 gauge steel sheet.
- I. Escutcheon Plates: Provide one piece or split-hinge-type metal plates for piping passing through walls in exposed finished areas. Provide chromium-plated or color-coordinated metal plates where pipe passes through finished ceilings. Securely anchor plates in proper position. Provide sprinkler escutcheon plates to match sprinkler head finish.

## 2.2 SPRINKLER HEADS

- A. Unless otherwise specified or required by NFPA 13, sprinkler heads shall have ordinary temperature classification. Heads located within the air streams of unit heaters or other heat-emitting equipment, skylights, or similar environmental conditions shall be selected for proper temperature rating and incorporate a glass bulb type fusible link. Heads installed where they might receive mechanical injury, or are at less than 7 feet, shall be protected with approved guards in accordance with NFPA 13.
- B. Sprinkler heads shall be pendant type, quick-response, white-on-white finish,

semi-recessed. All fittings with sprinkler heads shall have 1" outlets with 1" x 1/2" bushings. Sprinkler heads in mechanical and utility areas shall be upright type, standard brass. Semi-recessed heads shall be installed in the shell system per manufactures listing. Finish escutcheon shall not be installed, however, Contractor shall provide owner with adequate number of remaining escutcheon pieces once system has been accepted.

### 2.3 VALVES

- A. Provide valves as required by NFPA 13 and types UL listed or FM approved for fire protection service.
- B. Gate Valves: Gate valves shall be the outside stem & yoke (OS&Y) type, and open by counterclockwise rotation. Gate valves installed higher than 7 feet above the floor shall be provided with a chain drive or permanently metal mounted approved ladder.
- C. Check Valves: Check valves shall be clear-opening, swing-check type, with a bronze or stainless steel seat ring and a EPDM rubber clapper facing. Check valves of sizes 4 inches and larger shall have inspection and access cover plates.

### 2.4 ALARMS

- A. Paddle-Type Water Flow Switches: Water flow switches shall be vane type with time delay and two independent switches with pressure rating of 150 psi.
- B. Valve Supervisory Switches: Valve supervisory switches shall be installed on all sprinkler control valves. The switches shall be mounted so as not to interfere with the normal operation of the valve and shall be adjusted to operate within two revolutions of the valve control or when the stem has moved no more than 1/5 of the distance from its normal open position. The mechanism shall be contained in a weather-proof, die-cast, aluminum housing that shall be provided with a 1/2 inch tapped conduit entrance and incorporate the necessary facilities for attachment to the valve. Switch housing shall be finished in red baked enamel. The entire installed assembly shall be tamper-proof and arranged to cause a switch operation if the housing cover is removed or if the unit is removed from its mounting.

### 2.5 CABINET

- A. Furnish and install a metal cabinet containing a stock of spare sprinkler heads of all types and ratings installed. The cabinet shall be located near the riser assembly. The number and type of spare sprinkler heads shall be as required by NFPA 13.

### 2.6 BACKFLOW PREVENTERS

- A. Furnish and install an ASSE 1015 double-check backflow prevention assembly, consisting of shutoff valves on inlet and outlet and strainer in inlet. Include test cocks with two positive-seating check valves for continuous pressure application. Pressure loss shall be 5 psig maximum, through middle

third of flow range.

## 2.7 HOSE VALVES

- A. Provide UL 668, 300-psig minimum rating, brass, nonadjustable type, 2-1/2 inch hose valve for connection of fire hose. Include 90 degree angle pattern design, female NPS inlet and male hose outlet, 1-1/2 inch reducer, and lugged cap, gasket, and chain. Hose valve threads are according to NFPA 1963 and match local fire department threads. Finish shall be factory brass

## 2.8 FIRE DEPARTMENT CONNECTIONS

- A. Flush, Wall-Type Fire Department Connection: UL 405, cast-brass body, NH-standard thread inlets according to NFPA 1963 and matching local fire department thread; and threaded NTS outlet. Include lugged cap, gasket, and chain; lugged swivel connection, extension pipe nipple, and clapper for each hose connection inlet; and wall escutcheon plate with marking "AUTO SPKR & STANDPIPE." With chrome finish.

# PART 3 - EXECUTION

## 3.1 INSTALLATION

- A. Equipment, materials, installation, workmanship, examination, inspection and testing shall be in accordance with NFPA 13, except as modified herein. Install piping straight and true to bear evenly on hangers and supports. Install piping as close to the floor or roof deck as possible, without interfering with other equipment and construction. Nipples shall be perpendicular to ceilings. Keep the interior and ends of all piping affected by Contractor's operations thoroughly clean of water and foreign matter by means of plugs or other approved methods. Inspect piping before placing into position. All pipe, fittings, and gaskets are to be cleaned of oil prior to installation.

## 3.2 FIELD CHANGES

- A. Do not make field changes in the piping layout, pipe sizes, or type of equipment, without the prior approval of the Engineer of Record.

## 3.3 FIELD TESTING AND FLUSHING

- A. All testing shall be scheduled with the Owner or a designated representative. Hydrostatic tests shall be conducted at 200 psi for a 2 hour period with no leakage or reduction in gauge pressure. Hydrostatic test pressures shall not be maintained on the system overnight. Flush piping with potable water in accordance with NFPA 13. Water for testing and flushing shall be furnished by the Owner.
- B. Preliminary Tests and Procedures: Test the valve tamper switches, water flow switches, and other devices. Test the water flow alarms by flowing water through the inspector's test connection. In areas where piping will be

concealed by ceilings, walls, or other construction before the system is complete and ready for final testing, the preliminary hydrostatic test shall be conducted prior to piping being concealed. This test shall be witnessed by the Owner or a designated representative. When all tests and procedures are completed and corrections made, submit a signed and dated certificate, similar to that specified in NFPA 13, with a request for formal inspection and tests.

- C. Formal Inspection and Tests: At this time, all piping, sprinklers, and other system components shall be in place and all adjustments to the system completed. The Owner or a designated representative shall be notified by the Contractor and shall witness all tests and approve all systems before they are accepted. Submit a request for a formal inspection at least five working days prior to the date the inspection is to take place. A competent representative of the sprinkler installer shall be present during testing and inspection. As-built drawings shall be on-site for the inspection. At this inspection, the system shall be hydrostatically tested. Any or all of the required tests shall be conducted by the Contractor at his own expense and additional tests made until it has been demonstrated that the systems comply with all contract requirements. The Contractor shall furnish all appliances, equipment, instruments, connecting devices and personnel for the tests. Any costs incurred by the Owner for repeat tests, due to the failure of the Contractor to adequately demonstrate that the system complies with the contract requirements, shall be borne by the Contractor.

**END OF SECTION**

**SECTION 22 0000**  
**PLUMBING**

PART 1 - GENERAL

1.01 WORK INCLUDED

- A. Provide complete plumbing systems including piping, fixtures, equipment, as shown and specified.
- B. Provide complete site utilities systems and connections to existing as shown and specified.

PART 2 - PRODUCTS

2.01 PIPE AND FITTINGS

- A. Domestic Hot Water, Cold Water
  - 1. Building interior
    - a. Above ground: Type "L" hard copper with wrought copper fittings and 95/5 solder joints with no lead.
    - b. Building entrance: Use any of following:
      - (1) Type "K" soft copper with no joints below slab.
      - (2) Type "K" hard copper with wrought copper fittings and brazed joints.
      - (3) Type "K" hard copper with "press-fit" fittings and joints.
- C. Sanitary Drainage and Vent
  - 1. Building interior:
    - a. Service weight cast iron, either no-hub ends with elastomeric seals and stainless steel clamps or bell-and-spigot ends with elastomeric joints.
    - b. PVC or ABS as approved by the Regional Building Department
  - 2. Building exterior: Use any of following as approved by jurisdictional authorities:
    - a. Service weight cast iron with bell-and-spigot ends and elastomeric joints.
    - d. PVC per ASTM D3034, SDR 35, bell-and-spigot ends, elastomeric joints.
- D. Roof Drain Leaders – Same as sanitary drainage
- E. Equipment Drains and Overflows: Use any of following:
  - 1. Type "M" or DWV hard copper with sweat fittings, 50/50 solder.
  - 2. PVC with solvent weld fittings where approved.

F. Natural Gas

1. Building interior:
  - a. Concealed locations: Sch 40 black steel per ASTM A53, welded or flanged joints, grade WPB fittings per ASTM A234, grade I 150 lb. forged steel slip-on or weld neck flanges per ASTM A181, grade B regular square head flange bolts with heavy hex nuts per ASTM A307, 1/16" thick preformed synthetic rubber gaskets.
  - b. Exposed location, 1-1/2" and smaller: Sch 40 black steel per ASTM A120, screwed joints, 150 lb. malleable iron fittings per ASTM A197.
  - c. Exposed location, 2" and larger: Same as for concealed locations.
2. Building exterior: Use following as approved by jurisdictional authorities:
  - a. Above grade: Same as within building.
  - b. Buried: Sch 40 black steel per ASTM A53, welded joints, coated and wrapped per utility company requirements, cathodically protected as required. Or, approved plastic gas pipe.
  - c. Meter risers: Per utility company.

2.02 FIXTURES

- A. General: All exposed trim and piping shall be chrome plated.
- B. Provide fixtures as scheduled on the drawings.

2.03 METERS

- A. Gas: Furnished by Utility Company.
- B. Water: Furnished by Utility Company specs.

PART 3 - EXECUTION

3.01 WATER SYSTEMS

- A. General:
  1. Keys: Deliver hydrant keys, hose bibb keys, stop keys, valve wrenches, etc., at project completion.
  2. Disinfection
    - a. General: Disinfect all potable water systems. Test, clean and flush piping prior to disinfection.
    - b. Disinfectant: Use liquid chlorine or sodium hypochlorite solutions; gaseous chlorine not permitted. Minimum concentration: 50 ppm.
    - c. Procedure: Charge piping systems with disinfectant. Retain in system for minimum 8 hour contact period during which time open and close all valves and faucets at least three times.
    - d. Flush: At end of contact period, flush system with potable water until residual chlorine content is less than 0.2 ppm.

B. Building interior

1. General: Use materials specified for within building. Extend to 5 feet Building exterior.
2. Testing: Use 150 psig hydrostatic test.

3.02 DRAINAGE SYSTEMS

A. Building interior

1. General: Use materials specified for within building. Extend to 5 feet Building exterior.
2. Minimum Slope
  - a. Soil, waste, vent: 1/4" per foot for piping 4" and smaller, 1/8" per foot for piping 6" and larger.
  - b. Roof drainage: 1/8" per foot or as shown on Drawings.
3. Flashing
  - a. Material: 24" x 24" 4 lb. sheet lead.
  - b. Vents: Provide for all vents through roof. Extend flashing 5" above vent and turn down into pipe so as not to restrict or constrict the vent openings.
  - c. Drains: Provide for all drains located in waterproofed floors and roofs. Center drain on flashing. Clamp flashing into drain flashing collar.
4. Prohibited Practices
  - a. Bushings not allowed.
  - b. Vents within 24" of parapets, roof edge, crickets, or adjacent wall not allowed.
5. Drain and Cleanout Protection
  - a. Provide test plugs in drains and cleanouts at time of installation to prevent the entrance of foreign matter. Leave plugs in place during construction. Replace plugs immediately with proper strainer/grate/dome when flooring/roofing is completed. Caution! Take all measures necessary to prevent structural failure as a result of water ponding.
  - b. Protect strainers and cleanouts in finished areas during construction with self-adhesive tape. Replace as needed. Remove tape completely at project completion.
6. Cleanouts: Provide where shown and required, for proper cleaning of entire drainage system. Provide full size of pipe on which installed, 4" maximum.
7. Testing: Plug low points of system. Fill with water to uppermost outlet or to 12 feet high, whichever is greater. Let system stand full of water with no indication of leaks.

### 3.03 NATURAL GAS SYSTEMS

#### A. Building interior

1. General: Use materials specified for within building.
2. Installations: Install per applicable codes and ordinances and per NFPA 54. Piping shall rise above grade prior to entering building. Make equipment connections with gas cock and union.
3. Testing:
  - a. Use either of following methods:
    - (1) 50 psig air test for 24 hours without pressure loss.
    - (2) Soap test all joints with 100 psig air pressure within piping.
  - b. Only the last connection to the appliance may be tested under operating conditions. Leak test this connection under operating pressure. This connection must remain exposed.

#### B. Building exterior

1. General: Use materials specified for on site.
2. Minimum bury: 2'-6".
3. Installation: Per Utility Company requirements. Field wrap all buried joints same as for pipe. Provide cathodic protection as required.
4. Testing: Per Utility Company requirements.

### 3.04 FIXTURES, EQUIPMENT

- A. General: Set fixtures and equipment level and plumb. Securely mount to prevent any movement. Locate fixtures in accordance with Architectural Drawings paying particular attention to ADA requirements.
- B. Fixture Mounting Height: Comply as applicable with Architectural Drawings, manufacturers' installation instruction, governing codes regarding ADA access.
- C. Flush Valves: Securely anchor within wall so as to prevent movement due to operation of the valve.
- D. Aerators: Remove during construction. Install following system disinfection.

### 3.05 ADJUSTMENTS

- A. At project completion, adjust all plumbing systems, fixtures and equipment for proper operation under maximum flow/demand conditions.

**END OF SECTION**



**SECTION 22 0700  
PLUMBING INSULATION**

**PART 1 - GENERAL**

**1.01 WORK INCLUDED**

- A. Provide insulation as shown and specified herein.

**1.02 QUALITY ASSURANCE**

- A. Fire Hazard Classification: Tested as a composite in accordance with ASTM E84 or NFPA 255 or UL723 and so labeled. Max flame spread = 25, max smoke developed = 50.
- B. Energy Conservation: Comply with applicable energy codes.
- C. Prohibited Materials: Products or materials containing asbestos are expressly prohibited.

**PART 2 - PRODUCTS**

**2.01 PIPE INSULATION - MATERIALS**

- A. Acceptable Manufacturers: Manville, Certainteed, Owens-Corning, Armstrong.
- B. Fiberglass: ASTM C547 Type 1. Maximum k/inch = 0.22 at 75 degrees F. All service jacket with self-sealing laps. Pre-molded fitting and valve covers with fiberglass inserts.
- C. Flexible Closed Cell Elastomeric: ASTM C534 Type 1, and ASTM D1056. Maximum k/inch = 0.28 at 75 degrees F.
- D. All insulation shall have a maximum flame spread of 25, and developed smoke factor of 50 in accordance with ASTM E 84.

**PART 3 - EXECUTION**

**3.01 GENERAL**

- A. Apply insulation after systems have been tested.
- B. Comply with manufacturers recommendations regarding ambient and system temperatures and application methods.
- C. Apply insulation to clean, dry surfaces.
- D. Apply insulation with sections or edges firmly butted together.
- E. Run insulation continuous through sleeves and openings in walls and floors.

- F. Maintain integrity of vapor barrier on cold systems. Avoid the use of staples on vapor barrier. Seal all vapor barrier penetrations.
- G. Repair insulation damaged due to strain or poor workmanship.
- H. Leave surfaces clean and ready for painting.
- I. Insulation which has been applied in an unsightly manner will be ordered replaced.

### 3.02 PIPE INSULATION - INSTALLATION

- A. General
  - 1. Insulate pipe, fittings and valves.
  - 2. Do not insulate unions, flanges, strainers, flexible connections, expansion joints. Terminate insulation neatly with insulating and finishing cement troweled on a bevel.
  - 3. Insulated through hangers and supports. Use heavy density insert and sheet metal shield on 2" and larger, sheet metal shield on 1½" and smaller..
  - 4. For cold piping, seal fitting/valve covers at end and throat.
- B. Use
  - 1. Fiberglass with longitudinal seams located away from normal lines of sight.
  - 2. Fiberglass with metal jacket secured with draw bands 12" OC and sealed weather tight. For horizontal piping locate longitudinal seam and drawband clamp on underside of pipe. For girth joints in vertical piping, wrap upper jacket section around the lower section.
- C. Thickness: Insulate piping systems with thickness indicated in Table 3.03C. Insulate entire system unless noted otherwise. Not all piping system types or sizes are necessarily used in this project.

**Table 3.03C**

INSULATION THICKNESS FOR PIPE SIZE

<u>PIPING SYSTEM</u>	<u>RUNOUTS TO 1"</u>	<u>1" TO 1-1/4"</u>	<u>1-1/2" TO 4"</u>	<u>5" TO 6"</u>	<u>8" &amp; UP</u>	<u>NOTES</u>
Domestic Cold Water	1/2"	1"	1"	1"	1"	1, 2
Domestic Hot Water	1"	1"	1-1/2"	1-1/2"	-	2
Domestic Circulated	1"	1"	1"	1"	-	2
Domestic Tempered	1"	1"	1"	1"	-	2
Roof Drain Leaders (steel)	-	-	1"	1"	1":	1, 3
Roof Drain Leaders (PVC)	-	-	1/2"	1/2"	1/2"	1, 3

Schedule Notes:

1. Maintain integrity of vapor barrier jacket.
2. Insulation not required on fixture headers and fixture risers in plumbing chase.
3. Insulate all above-ground horizontal lines and all lines in return air plenum.
4. Exterior only with sealed and banded metal jacket.

**END OF SECTION**



**SECTION 23 0000**  
**BASIC REQUIREMENTS**

1.01 GENERAL

- A. All provisions of the Contract Documents apply to the work of this Division.
- B. All Division 23 Sections are subject to the provisions of this Section.

1.02 SUMMARY OF WORK

- A. Work Included: Provide all labor, materials, equipment, and incidental items necessary for completely finished and operational mechanical systems.

1.03 DEFINITIONS

- A. Exposed: Exposed in mechanical rooms or rooms with finished walls or ceilings.
- B. Concealed: Located in pipe chases, furred spaces, attics, crawl spaces, above suspended ceilings, or all other locations not exposed to view.
- C. Provide: Furnish and install.

1.04 DIVISION OF RESPONSIBILITY

- A. Specification formatting which indicates a division in the mechanical work is for convenience only. It is not intended to delineate lines of responsibility between subcontractors and/or suppliers. Such delineation rests entirely with the contractor.

1.05 EXISTING CONDITIONS

- A. Existing conditions as shown are approximate. The accuracy or completeness of the drawings is not assured; actual conditions may vary from that shown. Verify all conditions prior to fabrication and installation of mechanical or plumbing system components.

1.06 PLANS AND SPECIFICATIONS

- A. Plans are diagrammatic. They indicate general intent, design and arrangement of systems. Provide all minor incidentals such as offsets, fittings, etc., as may be required even though not shown. Provide isolation valves and unions as called for in these specifications whether or not shown on drawings. Do not scale the plans; take dimensions from actual field conditions.

1.07 CODES AND REGULATIONS

- A. Conform to codes and regulations applicable at the project site.
- B. Call for inspections from local authorities as required.

- C. If discrepancies occur between contract documents and local regulations, the local regulations apply.
- 1.08 FEES AND PERMITS
- A. Obtain required permits.
  - B. Pay permit fees, construction fees, tap fees, inspection fees.
  - C. Development fees paid by owner.
- 1.09 COORDINATION
- A. Coordinate with other trades to assure orderly progress of the work and to assure proper fit in confined spaces.
  - B. Contractor to prepare coordination drawings to include ductwork, cable tray, sanitary waste lines, roof drain leaders, major electrical conduit, and major fire sprinkler lines.
- 1.10 QUALITY ASSURANCE
- A. Perform work in accordance with good trade practice and in a neat manner.
  - B. Adhere to manufacturers' recommendations.
- 1.11 PROTECTION
- A. Of People: Arrange barriers, signs, etc. as required to minimize the hazard to people. Comply with applicable safety and health regulations.
  - B. Of Work: Take all measures necessary to protect the work both before and after installation, to assure that it will be in clean, undamaged, unblemished condition when turned over to the Owner. Repair/replace work damaged during construction.
- 1.12 RECORD DOCUMENTS
- A. Maintain at Job Site: Contract documents, reviewed submittals, field test records.
  - B. As-Built Drawings: Neatly revise the design drawings to reflect the as-built condition. Dimensionally locate site utilities and underslab work. Identify major valves in accordance with valve tag list. Deliver as-built drawings to Architect at project completion.
- 1.13 OPERATING & MAINTENANCE MANUAL
- A. Format: 8-1/2"x11" loose-leaf hard cover, permanently labeled. All contents typed or neatly lettered.
  - B. Contents: Each section set off by index tabs. Include:
    - 1. Table of Contents.
    - 2. Executed Warranties.

3. Name, address and telephone number of installing contractors and subcontractors, along with brief description of their project responsibility.
4. Name, address and telephone number of material and equipment suppliers, along with listing of items supplied.
5. Brief narrative on each system including:
  - a. System description.
  - b. System start, operation, shutdown procedures.
  - c. Emergency procedures for fire, failure, etc.
  - d. Preventive maintenance program including cleaning, replacement, adjustment, lubrication schedules.
6. Equipment tabs, minimum one tab for each applicable Division 15 Section, arranged in the same order as the specifications. Include for all equipment supplied:
  - a. Reviewed submittals.
  - b. Installation instructions.
  - c. Operating instructions.
  - d. Maintenance instructions.
  - e. Parts lists.
7. Balance report.
8. Certificates of Inspection

- C. At project completion submit one copy of manual to Engineer for review. Make any corrections required. Transmit three corrected copies to General Contractor for delivery to Owner.

#### 1.14 WARRANTIES

- A. Provide warranty addressed to Owner covering all Division 15 work in accordance with Division 1 of these specifications.
- B. Include executed warranties in Operating & Maintenance Manuals.
- D. During warranty period provide labor and materials to repair or replace defects in Division 15 work. Pay for damage to other work resulting from defects in Division 15 work.

#### 1.15 DEMONSTRATIONS

- A. Conduct demonstrations when systems are complete and operational and ready to be turned over to the owner, and after the Operating and Maintenance Manual is complete.
- B. Instruct the Owner's representative once on the proper operation and maintenance of the mechanical systems. Pay particular attention to normal and emergency start-up and shut-down procedures, seasonal change-over, safety devices, and temperature control systems.

#### 1.16 MECHANICAL AND ELECTRICAL COORDINATION

- A. Review ELECTRICAL documents to assure coordination between MECHANICAL and ELECTRICAL disciplines. Notify Architect of any discrepancies prior to ordering equipment.
- B. Notify General Contractor of changes in electrical characteristics of mechanical equipment substituted for that specified. Bear all costs associated with any electrical changes or additions required for substituted equipment not conforming to original specifications.

C. Provide equipment and labor in accordance with the following schedule as applicable unless indicated otherwise. For any items not scheduled below, provide and wire complete under Mechanical and Plumbing disciplines.

D. Refer to ELECTRICAL specifications for type of wiring required for all applications.

<u>ITEM</u>	<u>FURNISH UNDER</u>	<u>SET IN PLACE OR MOUNTED UNDER</u>	<u>POWER WIRING &amp; CONNECT UNDER</u>	<u>CONTROL WIRING &amp; CONNECT UNDER</u>
1. Packaged Equipment	MD	MD	ED(1)	MD
2. Equipment Motors	MD	MD	ED	MD
3. Motor Control Centers	ED	ED	ED	MD
4. Magnetic Motor Starters	MD	ED	ED	MD
5. Remote Push-Button Stations, Pilot Lights, HOA's	MD	MD	--	MD
6. Disconnect Safety Switches, Thermal Overload Switches, Motor Snap Switches	ED	ED	ED	--
7. Single Speed Line Voltage Operating Switch Legs	MD/ED(2)	ED/MD(2)	--	ED/MD(2)
8. Multi- or Variable-Speed Line Voltage Operating Switch Legs	MD	ED/MD(2)	--	ED/MD(2)
9. Line Voltage Thermostats	MD	ED	ED	--
10. Fire Sprinkler Controls, Switches, Alarms	MD	MD	ED	ED
11. Duct-mounted Fire and Smoke Detectors	ED/MD(3)	MD	ED	ED/MD(4)
12. 120V to Control Panels	ED	--	ED(5)	--
13. Remote Time Clocks	MD	MD	ED	MD
14. Controls	MD(6)	MD(6)	MD(6)	MD(6)
15. Device Labels	(7)	(7)	--	--

**FOOTNOTES:**

MD = Mechanical Division

ED = Electrical Division

(1) = ED will wire to terminal lugs on equipment. Any internal wiring required is the responsibility of the MD.

(2) = By ED when shown on electrical drawings, otherwise by MD.

(3) = By ED when project incorporates a central fire alarm system, otherwise by MD.

(4) = ED wires to fire alarm system. MD wires to fan controls.

(5) = ED will terminate wiring in a J-box near the panel; MD extend from box to panel.

(6) = All control work by MD unless specifically assigned to ED, regardless of voltage.

(7) = Furnished by the Division furnishing the device, installed by the Division installing the device

**END OF SECTION**



**SECTION 23 0500**  
**BASIC MATERIALS AND METHODS**

PART 1 GENERAL

1.01 WORK INCLUDED

- A. This Section describes materials and methods common to the work in general for Section 23.

PART 2 - PRODUCTS

2.01 MOTORS, STARTERS, MISC. ELECTRICAL

- A. Motors: Minimum horsepower as indicated herein or on drawings, constructed for operation at site altitude, dust proof/leak proof bearing rings, built to NEMA standards, factory balanced, open drip proof, thermal overload protected, 1.15 service factor at altitude, power factor corrected in accordance with applicable energy code, suitable for operation on voltage indicated.
- B. Magnetic Starters: Overload protection in each phase, fused control transformer with maximum 120V secondary, holding coils, integral HOA switch, integral red pilot light to signify "on", auxiliary contacts as required for system operation plus one spare.
- C. Manual Single-Speed Operating Switches: Maximum 120V, pilot duty or load rated as suits the application, with pilot light. Arrange light to extinguish if motor trips out on any safety device. Provide cover plate. See Section 26 for other requirements.
- C. Phase Reversal protection, single phasing protection: Provide for motors 10 horsepower and larger.
- E. Other Electrical Work: In accordance with Section 26.

2.02 SLEEVES, SAFING, AND ESCUTCHEONS

- A. Sleeves:
1. Round: Steel pipe sized large enough to allow for uninterrupted insulation and for movement.
  2. Rectangular: Galvanized steel, reinforced to prevent deformation.
- B. Safing:
1. Waterproof: Elastic mastic, silicone, etc.
  2. Fireproof: Plaster, grout, other material as approved by local authorities.
- C. Escutcheons
1. Piping: Adjustable nickel-plated, solid or split, flat or dished to suit the application.
  2. Ductwork: Fabricated sheet metal.

2.03 VALVES

- A. Acceptable Manufacturers: Apollo, Keystone, Crane, Hammond, Dezurick, Jenkins, Kennedy, Nibco, Powell, Stockman, Grinnell.
- B. General: All valves of the same type shall be of one manufacturer. Use valves listed with the Manufacturers Standardization Society of the Valve and Fitting Industry.
- C. Gate Valves
  - 1. 2" and smaller: Bronze, union bonnet, rising stem, inside screw, solid wedge, hand wheel, screwed or soldered ends, 150# WSP, 300# WOG.
  - 2. 2-1/2" and larger: iron body, bronze trim, rising stem, OS & Y, bolted solid wedge, hand wheel, flanged ends, 125# WSP, 200# WOG.
- D. Ball Valves
  - 1. 2" and smaller: Bronze, swing-away design, full port, bronze ball, teflon seat, lever operator, screwed or soldered ends, 150# WSP, 400# WOG.
  - 2. 2-1/2" and larger: Not applicable.
- E. Plug Cocks
  - 1. 2" and smaller: Bronze, swing disc, solder or screwed ends.
  - 2. 2-1/2" and larger: Iron body, bronze trim, lubricated, flanged ends.
- F. Check Valves
  - 1. Swing check 2" and smaller: Bronze, screwed bonnet, horizontal swing disc, renewable disc and seat, solder or screwed ends, 150# WSP, 300# WOG.
- G. Drain Valves
  - 1. Bronze, compression stop with nipple and cap or hose thread outlet, 125# WSP.
- H. Gas Cocks: Corrosion resistant plug, permanently lubricated, non-corrosion bearings, suitable seals for intended service, removable lever operator.

### PART 3 - EXECUTION

#### 3.01 MOTORS, STARTERS, AND MISC. ELECTRICAL

- A. Provide motors of minimum horsepower indicated, complete with starters, etc. where required. See Sections MECHANICAL AND ELECTRICAL COORDINATION and CONTROLS.
- B. Comply with the provisions of Division 16.

#### 3.02 SLEEVES, SAFING, AND ESCUTCHEONS

- A. Make penetrations through building elements as follows:
  - 1. New concrete: Use individual sleeves cast in place. Only one pipe or duct to a sleeve; multiple pipes/ducts in a sleeve not allowed. Sleeve for pneumatic control tubing bundles

- same as for pipes. Extended floor sleeves 2" above finished floor, notched as required for riser clamps. Cut wall sleeves flush with wall.
  - 2. Pre-cast and existing concrete, sleeves not required. Saw cut or core drill concrete as in accordance with paragraph CUTTING AND PATCHING herein.
  - 3. New masonry: Same as new concrete.
  - 4. Existing masonry: Same as existing concrete.
  - 5. Frame: Same as existing concrete.
- B. Provide safing in annular space between pipe/duct/insulation and sleeve/opening as follows:
  - 1. For un-rated concrete floors and foundation walls use waterproof type.
  - 2. For fire-rated construction use fireproof type for full thickness of the construction.
- C. Provide escutcheons for pipes and ducts passing through walls, floors and ceilings in finished areas. Provide to completely conceal the penetration, to butt tightly against the wall/floor/ceiling and the pipe/duct, and to yield a neatly finished appearance. Install plated escutcheons after wall/floor/ceiling has been painted.

### 3.03 EXCAVATION AND BACKFILL

- A. Provide for all Division 23 work in accordance with other Divisions and the Soils Report.
- B. Trenching: Verify location of new and existing buried utilities prior to trenching; immediately repair/replace any utilities damaged due to trenching. Saw cut through asphalt and concrete. Over-excavate if required for proper bedding.
- C. Bedding: Remove rocks and stones from bottom of trench. Backfill and compact over-excavation using suitable material. Shape bedding to allow pipe to bear full length. Hand dig for bells.
- D. Trace Wires: Provide No. 6 bare copper trace wire in trench alongside any non-conductive piping, to facilitate future location. Terminate at both ends with secure electrical bond to valve box, grade cleanout, manhole frame, similar conductive item. Show terminal locations on as-built drawings.
- E. Backfill: Test piping prior to backfill; where test pressure may cause pipe movement, may backfill over piping keeping joints exposed for inspection. Remove rocks and stones from any backfill material which will be within 6" of pipe or buried ductwork. Backfill to 6" over pipe in at least 3 hand-tamped lifts compacted to the prescribed density. Backfill and compact remainder of trench in accordance with Division 2.
- F. Surface Restoration: Restore to original grade and condition.
- G. Settlement: Rectify any settlement which occurs during the warranty period. As part of Division 23 warranty, provide any asphalt/concrete patching as required to restore the surface.

### 3.04 EQUIPMENT BASES, SUPPORTS, AND MISC. STEEL

- A. Concrete: Provide housekeeping pads, inertia pads, bases, piers, etc. as shown or required for Division 15 work.

- B. Steel: Provide as shown or required for Division 15 work. Provide in accordance with AISC Specification for the Design, Fabrication and Erection of Structural Steel for Buildings. Brace and fasten with flanges bolted to structure.

### 3.05 FLASHING AND COUNTERFLASHING

- A. Roof penetrations: Provide roof jack, flashing, and counter flashing as appropriate for the roofing system
- B. Counterflashing, Saming: For Division 23 work, provide under Division 23. See appropriate Division 23 Sections.

### 3.06 CUTTING AND PATCHING

- A. General: Perform as required for Division 23 work. Keep to a minimum through proper scheduling. Where unavoidable, perform in accordance with applicable Divisions. See also other Divisions.
- B. Cutting: Obtain Architect's approval prior to cutting or drilling structural elements. Use saw or rotary drill; do not use pneumatic hammer.
- C. Patching: Seal openings, repair, refinish, restore damaged elements to original conditions. Comply with provisions of applicable Divisions.

### 3.07 ACCESS PANELS

- A. Furnish in accordance with Division 8 and with fire rating compatible with ceiling or partition rating. Furnish where indicated and at locations where required for access to concealed valves, dampers, cleanouts, control devices, equipment, other items requiring service/maintenance. Deliver to General Contractor for installation under other Divisions. Provide instructions for location.

**END OF SECTION**

**SECTION 23 0593**  
**TESTING, ADJUSTING AND BALANCING**

**PART 1 - GENERAL**

**1.01 WORK INCLUDED**

- A. At the completion of the mechanical installation, perform testing, adjusting and balancing of all mechanical systems provided under Division 23.

**1.02 QUALITY ASSURANCE**

- A. Work under this Section shall be performed by Midwest Engineering of Colorado Springs.
- B. Perform work and report findings in accordance with:
  - 1. ASHRAE Handbook chapter on Testing, Adjusting and Balancing.
  - 2. NEBB Procedural Standards for Testing, Adjusting and Balancing of Environmental Systems.

**1.03 SUBMITTALS**

- A. Submit detailed balance report in triplicate at completion of work. Include:
  - 1. Instruments used and date of last calibration.
  - 2. Equipment nameplate data.
  - 3. Data sheets showing all measurements taken and the final settings of all adjustable components.
  - 4. System schematics or reduced-scale prints marked to correspond to the data sheets.
  - 5. Commentary on any item not meeting design intent.

**1.04 PROJECT CONDITIONS**

- A. Verify following conditions before proceeding with work.
  - 1. Installation of the designated system is complete and in full operation.
  - 2. Outside temperature conditions, occupant loads, lighting loads, special equipment requiring extrasensible or ventilation requirements, and solar conditions are within a reasonable range relative to design conditions.

**PART 2 - PRODUCTS**

**2.01 REPLACEMENT ITEMS**

- A. Provide replacement sheaves and belts and replacement thermal overload elements which may be required to satisfy the actual job conditions.

**PART 3 - EXECUTION**

**3.01 PREPARATION**

- A. Air Systems: Check:

1. Filters are clean.
2. Filter leakage.
3. Damper operation and leakage.
4. Duct leakage.
5. Fan rotation.
6. Equipment vibration.

### 3.02 ADJUSTING AND BALANCING

- A. Equipment: Record make, model, size.
- B. Motors: Record voltage, max allowable and actual amp draw on each phase, thermal overload size, rpm, hp.
- C. Drives: Adjust so that when the desired speed and belt tension has been established, the variable sheave and the belt tension adjustment shall be at approximately the midpoint of the adjustment range. Record rpm.
- D. Air Systems: Adjust to CFM indicated and to obtain uniform space temperatures free from objectionable drafts and noise. Adjust fan systems and major quantities to within +-5%. Individual air outlets, when one of three or more serve a space, may have a tolerance of 10% from the average. Mark final setting of each balancing device. Record:
  1. Grilles, Registers, Diffusers: Ak, velocity, CFM.
  2. Fans: Supply CFM, return CFM, outdoor air CFM, exhaust CFM, RPM, SP at fan intake and discharge.
  3. Coils: Air temperature entering and leaving, CFM, air pressure drop.
  4. Filters: Air pressure drop, CFM.
  5. Major Duct Branches and Zones: CFM.
- E. Controls: In cooperation with Temperature Control Contractor, verify and adjust all control devices for proper operation.

### 3.03 COMPLETION SERVICES

- A. Final Check: Make final checks and do any re-balancing as directed.
- B. Report: Submit Balancing Report as specified above.

**END OF SECTION**

**SECTION 23 0700  
HVAC INSULATION**

**PART 1 - GENERAL**

**1.01 WORK INCLUDED**

- A. Provide insulation as shown and specified herein.

**1.02 QUALITY ASSURANCE**

- A. Fire Hazard Classification: Tested as a composite in accordance with ASTM E84 or NFPA 255 or UL723 and so labeled. Max flame spread = 25, max smoke developed = 50.
- C. Prohibited Materials: Products or materials containing asbestos are expressly prohibited.

**PART 2 - PRODUCTS**

**2.01 PIPE INSULATION - MATERIALS**

- A. Acceptable Manufacturers: Manville, Certainteed, Owens-Corning, Armstrong.
- B. Fiberglass: ASTM C547 Type 1. Maximum k/inch = 0.22 at 75 degrees F. All service jacket with self-sealing laps. Pre-molded fitting and valve covers with fiberglass inserts.
- C. Flexible Closed Cell Elastomeric: ASTM C534 Type 1, and ASTM D1056. Maximum k/inch = 0.28 at 75 degrees F.
- D. All insulation shall have a maximum flame spread of 25, and developed smoke factor of 50 in accordance with ASTM E 84.

**2.02 DUCT INSULATION - MATERIALS**

- A. Acceptable Manufacturers: Manville, Certainteed, Owens-Corning.
- B. Wrap: Fiberglass blanket in accordance with ASTM C553, Type 1, Class B3. R=2.8/inch at 75°F installed. FSK facing.
- C. Liner: fiberglass duct liner with coating on air-side surface. R=4.2/inch at 75°F
- D. All insulation shall have a maximum flame spread of 25, and developed smoke factor of 50 in accordance with ASTM E 84.

**PART 3 - EXECUTION**

### 3.01 GENERAL

- A. Apply insulation after systems have been tested.
- B. Comply with manufacturers recommendations regarding ambient and system temperatures and install in strict accordance with manufacturer's application methods.
- C. Apply insulation to clean, dry surfaces.
- D. Run insulation continuous through sleeves and openings in walls and floors.
- E. Maintain integrity of vapor barrier on cold systems. Avoid the use of staples on vapor barrier. Seal all vapor barrier penetrations.
- F. Leave surfaces clean and ready for painting.

### 3.02 PIPE INSULATION - INSTALLATION

- A. General
  - 1. Insulate pipe, fittings and valves.
  - 2. Do not insulate unions, flanges, strainers, flexible connections, expansion joints. Terminate insulation neatly with insulating and finishing cement troweled on a bevel.
  - 3. Insulated through hangers and supports. Use heavy density insert and sheet metal shield on 2" and larger, sheet metal shield on 1½" and smaller..
  - 4. For cold piping, seal fitting/valve covers at end and throat.
- B. Use
  - 1. Fiberglass with longitudinal seams located away from normal lines of sight.
  - 2. Fiberglass with metal jacket secured with draw bands 12" OC and sealed weather tight. For horizontal piping locate longitudinal seam and drawband clamp on underside of pipe. For girth joints in vertical piping, wrap upper jacket section around the lower section.
- C. Thickness: Insulate piping systems with thickness in strict conformance to the 2009 *International Conservation Code*.

### 3.03 DUCT INSULATION - INSTALLATION

- A. Duct Liner: Apply liner with 100% adhesive coverage. Butter all raw edges with adhesive. Adhere to manufacturers' recommendations regarding mechanical fasteners and nosings.
- B. Duct Wrap: Adhere to duct exterior with 100% adhesive coverage. Seal all joints and punctures to maintain integrity of vapor barrier on cold air ducts.
- C. Duct Board: Fasten to duct with weld pins or stick clips spaced in accordance with manufacturer's recommendations, secured with washers. Seal joints, breaks and punctures in cold air ductwork with adhesive reinforced with a 3" wide strip of facing material.
- D. Insulate ductwork as indicated in Table 3.03D unless specifically indicated otherwise herein or on the drawings.



**Table 23A**

DUCTWORK INSULATION REQUIREMENTS

DUCT SYSTEM TYPE	NONE REQ'D	DUCT LINER	DUCT WRAP	DUCT BOARD
ALL DUCTS EXPOSED IN CONDITIONED SPACE	X			
RECTANGULAR SUPPLY & RETURN AIR		X		
ROUND SUPPLY & RETURN AIR			X	
OUTSIDE AIR			X	
OUTSIDE AIR PLENUMS				X

- E. All duct insulation thicknesses shall be in strict accordance with the 2009 *International Energy Conservation Code*.
- F. All exhaust ductwork within 10 feet of exhaust registers shall be insulated with ½" duct liner. Omit all insulation from exhaust ductwork serving Type I or Type II hoods.

**END OF SECTION**



**SECTION 23 3000**  
**AIR DISTRIBUTION**

**PART 1 - GENERAL**

**1.01 WORK INCLUDED**

- A. Furnish and install ductwork and sheetmetal accessories as shown and specified herein.

**1.02 QUALITY ASSURANCE**

- A. Comply with applicable NFPA and SMACNA standards, ASHRAE Handbook, UL 181, and UMC.

**1.03 SUBMITTALS**

- A. In addition to all items scheduled on the Drawings, furnish submittals on all items specified here-in.

**PART 2 - PRODUCTS**

**2.01 DUCTWORK MATERIALS**

- A. Galvanized Steel
  1. Gauge: As prescribed by code.
  2. Flat sheets: ASTM A527.
  3. Round:
    - a. Fabrication: Pipe lock longitudinal seams with beaded crimp transverse joints secured with sheetmetal screws.
    - b. Fittings: Adjustable 4-segment elbows, manufactured conical tee fittings and taps (saddle taps not permitted), manufactured register boots and stack heads.

**B. Flex Duct:**

1. Acceptable Manufacturers: Flexmaster.
2. Classification: NFPA 90A - Class 1, UL 181 labeled.
3. Low pressure: Flexmaster Type 5-Insulated. Factory fabricated assembly consisting of a zinc-coated spring steel helix, seamless inner liner wrapped with a nominal 1" thick one-pound density fiberglass insulation all assembled in a vapor barrier jacket. Rated for pressures to +3" WG.
4. Spin-ins: With balancing damper.

**2.02 DUCTWORK SPECIALTIES**

- A. Balancing Dampers
  1. Acceptable Manufacturers: Dowco, Young Regulator.
  2. Construction: Rigid bearings and locking quadrants. Where used in conjunction with duct-mounted coils, provide opposed-blade type with max 2" wide blades.
- B. Access Doors
  1. Acceptable Manufacturers: CESCO.

- 2. Hinged door with housing frame, sash-type closures, door of two gauges heavier than duct, sponge rubber gaskets cemented in place.
  - C. Flex Connections
    - 1. Ventfabrics Ventglas
  - D. Test Hole.
    - 1. Low velocity ductwork: Drilled hole with friction-fit plastic cap on metal duct and tape closure on fiberglass ductboard.
    - 2. Medium pressure ductwork: Ventlock No. 699 with gasketed threaded removable cap and gasketed base connection at duct wall.
  - E. Manufactured Duct Connection System
    - 1. Ductmate 25 or 35 as applicable.
  - F. Duct Sealants
    - 1. Hardcast Iron-grip 601 cement
    - 2. Hardcast Aluma-grip 701 tape
- 2.03 GRILLES, REGISTERS, DIFFUSERS
- A. Acceptable Manufacturers: Carnes, Krueger, Titus, Anemostat, Agitair, Metal-Aire.
  - B. Sizes, Types: See schedule on Drawings.

PART 3 - EXECUTION

3.01 LOW VELOCITY DUCTWORK

- A. Application: All ductwork is classified as low velocity unless indicated otherwise.
- B. Fabrication:
  - 1. In accordance with SMACNA and ASHRAE standards for low velocity ductwork.
  - 2. Manufactured duct connection system may be utilized for transverse joints in rectangular galvanized steelductwork. Provide in strict accordance with manufacturer's recommendations.
- C. Materials:
  - 1. Exposed: Galvanized steel.
  - 2. Concealed: Galvanized steel.
- D. Flex: Low-pressure type.

3.02 DUCTWORK FABRICATION AND INSTALLATION

- A. General
  - 1. Fabricate and install to meet job conditions from dimensions taken from jobsite and shop drawings. Transition as required to avoid interferences; maintain required cross-sectional area.
  - 2. Fabricate and install so no undue noise or vibration results.
  - 3. Do not provide holes in the duct systems for the installation of hangers, conduit, pipes, etc.

4. Duct dimensions on drawings are clear inside dimension; increase sheetmetal dimensions to accommodate liner.
  5. Locate all ductwork concealed unless indicated otherwise.
- B. Elbows
1. Curved: Center line radius equal to 1-1/2 times the duct width.
  2. Square: Fitted with turning vanes.
- C. Take-Offs: 45° connection at all take-offs in rectangular ductwork. Straight spin-in with damper for round run-outs.
- D. Hangers and Supports
1. Horizontal ducts: Provide hangers of type and spacing as recommended by SMACNA.
  2. Vertical ducts through floors: Provide galvanized steel angles on at least two sides of the duct; fasten securely to duct and floor.
- E. Balancing Dampers: Provide for proper adjustment and control of air distribution. Mark damper rod to indicate the relative position of the damper blades with respect to the rod.
- G. Access Doors: Provide in ductwork for access to all automatic dampers, fire dampers, coils, other items requiring maintenance or inspection. Provide 12" x 12" doors where permitted by duct size; where duct is too small provide as large a door as possible.
- H. Flex Ductwork: Use lengths not exceeding ten feet as necessary to make connection without pinching or kinking. Suspend horizontal runs with 3/4" wide flat steel band at 36" OC. Make end connections with steel draw bands.
- I. Flex Connections: Provide at inlet and outlet to all fans.
- J. Test Holes: Provide on branch and main duct to provide openings through duct walls for the insertion of test equipment. Locate to enable traverse readings per ASHRAE Standards.
- K. Painting: Where interior of duct is visible through grilles, louvers, etc., paint visible inside portion of duct with flat black paint.
- F. Seal all joints with duct sealant, tape or cement.

**END OF SECTION**



**SECTION 23 3410  
EXHAUST FANS**

**PART 1 - GENERAL**

**1.01 WORK INCLUDED**

- A. Provide exhaust systems in accordance with the drawings and this Section to yield a complete exhaust system.

**PART 2 - PRODUCTS**

**2.01 GENERAL EXHAUST FANS**

- A. Acceptable Manufacturers: Carnes, Greenheck, Penn, Acme, Loren Cook
- B. Housing: All aluminum with either upblast or radial discharge as indicated by model number, with motor compartment out to the primary air stream, removable cover.
- C. UL 705 listed
- D. Inlet: Spun aluminum venturi
- E. Wheel: Centrifugal, aluminum, statically and dynamically balanced
- F. Drive: Direct drive or adjustable belt drive as indicated by model number, resiliently mounted, with ball bearing pillow blocks on wheel shaft.
- G. Motor: Permanently lubricated ball bearing type.
- H. Accessories:
  - 1. Standard 12" insulated curb
  - 2. Gravity backdraft damper
  - 3. Pre-wired disconnect switch

**2.02 CEILING EXHAUST FANS**

- A. Acceptable Manufacturers: Broan, Carnes, Greenheck, Penn, Acme, Loren Cook.
- B. Housing: galvanized steel housing insulated with at least 1/2" of acoustic insulation. Housing to have adjustable mounting brackets. Automatic backdraft damper to be located within duct connector. Duct connector, blower assembly, and wiring plate shall be adjustable for either horizontal or vertical installation.
- C. Blower unit: shall be removable from housing and will have a polymeric, dynamically balanced centrifugal-type blower wheel. Motor to be permanently lubricated and mounted with resilient anti-vibration mounts. RPM not to exceed number listed for each model.

- D. Air delivery shall be no less and sound levels no greater than listed for each model. All air and sound ratings shall be certified by AMCA. Units to be UL and cUL listed.

### PART 3 - EXECUTION

#### 3.01 INSTALLATION

- A. Install per Drawings and manufacturers' recommendations.
- B. Provide 1 year limited parts warranty

**END OF SECTION**



**SECTION 23 36 16**  
**AIR TERMINAL UNITS - VARIABLE VOLUME**

**PART 1 GENERAL**

**1.01 SECTION INCLUDES**

- A. Fan powered terminal units.
  - 1. Parallel flow (variable volume).
  - 2. Series flow (constant volume).
- B. Integral heating coils.
  - 1. Electric resistance.
  - 2. Hot water.
- C. Sound attenuator.
- D. Integral terminal unit controls.
  - 1. Direct digital.

**1.02 REFERENCES**

- A. NFPA 90A - Installation of Air Conditioning and Ventilation Systems.
- B. UL 181 - Factory-Made Air Ducts and Connectors.
- C. NFPA 70 - Electric Duct Heaters.
- D. UL 1995, Heating and Cooling Equipment.
- E. CUL C22.2 No. 236, Heating and Cooling Equipment.
- F. ARI 880 - Air-Conditioning and Refrigeration Institute Standard Rating Conditions for Air Terminals
- G. ASTM A 527 (Steel Sheet, Zinc Coated Galvanized).
- H. A-A-1419 or F-F-310 Federal specification (filter element, Air conditioning, Viscous-impingement or Dry type, replaceable), Tested per UL 900.

**1.05 SUBMITTALS**

- A. Submit shop drawings and product data sheets indicating configuration, general assembly, and materials used in fabrication.
- B. Submit product performance data indicating design air flow, minimum static pressure drop, fan operating condition.
- C. Submit installation, operation and maintenance documentation.

1.06 QUALIFICATIONS

- A. Manufacturer: The company manufacturing the products specified in this section shall have a minimum of ten years experience producing products of this type.

1.07 SYSTEM RESPONSIBILITY

- A. The contractor shall be responsible for any and all costs associated with any and all changes resulting from the use of a supplier other than the listed acceptable manufacturers.

1.08 WARRANTY

- A. Provide manufacturer's parts warranty for one year from unit start-up or eighteen months from unit shipment, whichever is shorter.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. General
  - 1. Manufacturer shall participate in the ARI Certification program. Unit performance data shall be rated in accordance with ARI Standard 880. The manufacturer shall display the ARI Symbol on all units.
  - 2. Single and dual duct terminal units shall be UL listed as an entire assembly.
  - 3. Fan powered terminal units shall be UL listed as an entire assembly.
- B. Base bid shall be Trane VAV air terminal units with approved alternate being Carrier or York. Alternates must still comply with the performance and features as specified with these specifications and indicated on the design documents. Job will be awarded on basis of specified product. Substitutions must be selected and approved within 14 calendar days after award of contract.

2.02 MANUFACTURED UNITS

- A. Fan powered terminal units.
  - 1. Ceiling mounted primary and recirculated air control terminal unit for connection to a single medium - 1.5-3.0 in. wg. pressure duct of a central air distribution system. Terminals units may be provided with controls and integral heating coils.
- B. Identify each terminal unit with clearly marked identification label and airflow indicator. Label shall include unit nominal air flow, maximum factory-set air flow, minimum factory-set air flow, and coil type.

2.03 FABRICATION

- A. Casings: Units shall be completely factory-assembled, manufactured of corrosion protected steel, and fabricated with a minimum of 18-gauge metal on the high pressure (inlet) side of the terminal unit damper and 22-gauge metal on the low pressure (outlet)

side and unit casing.

- B. Plenum air filters shall be provided on all fan powered units.
- C. INSULATION - Matte Faced - The interior surface of unit casing acoustically and thermally lined with a minimum of 1/2 inch, 1.75 lb./cu. ft. density glass fiber with a high density facing. The insulation R-Value shall be a minimum of 1.9. Insulation shall meet NFPA-90A and UL 181 requirements.
- D. INSULATION EDGE TREATMENT - All cut edges of insulation shall completely enclosed by metal to arrest cut fibers and prevent erosion into the airstream.
- E. Assembly: Primary air control damper, airflow sensor, fans, controls and optional heating coil in single cabinet.
- F. Rectangular Supply Air Outlet Connections: Rectangular outlet connections for single duct units shall be slip and drive type. Rectangular outlet connections for dual duct and fan powered units shall be flanged type.

#### 2.04 PRIMARY AIR CONTROL DAMPER ASSEMBLY

- A. Locate primary air control damper assembly inside unit casing. Construct the damper assembly from extruded aluminum and/or a minimum 20 gauge galvanized steel components. Maximum damper leak rate shall not exceed 1% of damper nominal CFM at 4 inch wg. differential.
- B. Provide damper assembly with integral flow sensor. Flow sensor shall be provided regardless of control type. Flow sensor shall be a multi-point, averaging, ring or cross type. Bar or single point sensing type is not acceptable.

#### 2.05 HEATING COILS

- A. Electric Resistance Heating Coil: Coil shall be factory installed and wired and shall be constructed of open-wire type resistance heat elements. Coils shall be provided with primary and secondary over-temperature protection. Coils shall be constructed for single point power connection. Controls shall consist of an integral control box which includes a 24 VAC transformer and magnetic contactors. Electric heat coil shall be installed at the terminal unit supply air outlet connection.
  - 1. All single duct terminal unit electric heat coils shall be furnished with an airflow switch to disable the coil upon a low flow condition.
- B. Capacity: Provide coils in capacities as scheduled on the drawings.

#### 2.06 FAN ASSEMBLY

- A. Fan assembly shall be forward curved centrifugal fan with direct drive permanently lubricated, permanent split-capacitor type, thermally protected motor. Motor must be capable of continuous operation under maximum fan load with no external static pressure. Provide unit with a SCR motor speed adjustment that is factory-installed and wired to the fan motor.
- B. Fan motor horsepower shall not exceed the horsepower scheduled for each unit. Fan motors shall be high efficiency and shall not exceed those shown in the table below for each motor size.

	115 Volt	277 Volt	347 Volt
FAN HP	AMPS	AMPS	AMPS
1/15	1.5	1.3	0.4
1/8	2.7	1.3	1.1
1/3	7.4	2.9	3.6
1/2	11.4	4.4	4.3

- C. Internally suspend and isolate fan motor assembly from unit casing by using rubber isolators or torsion flex mounting legs.
- D. Unit shall be equipped with a fan motor disconnect switch which breaks both legs of power entering the control box.

2.07 WIRING

- A. Factory install and wire power line fusing, a disconnect switch and a 24 VAC transformer for control voltage on fan powered direct digital or electronic control units. Provide terminal strip in control box for field wiring of thermostat and power source.
- B. Factory install and wire all terminal unit fan controls. Install electrical components in control box with removable cover. Incorporate single point electrical connection to power source.
- C. Control Transformer - Provide single and dual duct terminal units with a factory installed and wired 24 VAC transformer to provide control voltage power to the unit.

2.08 DIRECT DIGITAL VAV CONTROLS

A. Direct Digital Controls

1. General. Direct digital controls (DDC) and factory costs to mount, calibrate and test the system shall be the responsibility of Section 15900 Automatic Temperature Control (ATC) / Building Automation System (BAS) Contractor.
2. Terminal unit manufacturer shall provide price for factory or field mounting, continuity check, calibrating, and testing of direct digital controls to the automatic temperature controls contractor.
3. Multi-point, multi-axis flow ring or cross sensor to be furnished and mounted by terminal unit manufacturer. Single point or flow bar sensors are not acceptable. Flow sensing device shall be capable of maintaining airflow to within +/- 5 percent of rated unit airflow setpoint when installed with 1.5 duct diameters straight duct, of the same size as the primary airflow inlet, upstream from the unit.

B. VARIABLE AIR VOLUME (VAV) TERMINAL UNIT CONTROL

1. The VAV terminal units shall be individually controlled by a DDC VAV controller per VAV terminal unit. The DDC VAV controller, damper motor, transducer and transformer shall be supplied by the BAS contractor and furnished to the terminal unit supplier. The cost to factory mount, calibrate and test the controller, transducer, transformer and actuator shall be coordinated prior to bid day and included in the BAS price.
  - a. To assure proper operation and control, the BAS contractor as part of this bid shall recalibrate the transducers six (6) months after acceptance of the BAS

system to correct any deviations as a result of transducer drift.

C. Zone Sensors

1. The zone sensor shall be accurate to within 0.5 F. The sensor shall be a product of the VAV box controls manufacturer and designed specifically for the installed controller.
2. The zone sensor shall have the following features:

2.09 TESTING / VERIFICATION

- A. Factory run-test all fan powered units.
- B. Factory set and check all analog electronic and pneumatic controllers to within 5% of scheduled maximum and minimum settings. Base performance on tests conducted in accordance with ARI 880.
- C. Maximum Casing Leakage: 1 percent of nominal air flow at 0.5 in wg inlet static pressure.
- D. Maximum Damper Leakage: 1 percent of design air flow at 4 in wg inlet static pressure.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install in accordance with manufacturer's instructions.

3.02 ADJUSTING

- A. Reset volume with damper operator attached to assembly allowing flow range modulation from 100 percent of design air flow to 25 percent nominal air flow for cooling only units and 30 percent for units with heating coils.

**END OF SECTION**



**SECTION 23 7420  
PACKAGED VAV ROOFTOP UNITS**

**PART 1 GENERAL**

**1.01 SECTION INCLUDES**

- A. Packaged rooftop unit.
- B. Heat exchanger.
- C. Refrigeration components.
- D. Unit operating controls.
- E. Roof curb.
- F. Electrical power connections.
- G. Operation and maintenance service.

**1.02 REFERENCES**

- A. ANSI/NFPA 90A - Installation of Air Conditioning and Ventilation Systems.
- B. ARI 360 - Unitary Air-Conditioning Equipment.
- C. ANSI/ASHRAE/IESNA 90.1-1999 - Energy Standard for New Buildings Except Low-Rise Residential Buildings.
- D. California Administrative Code - Title 24 Establishes the minimum efficiency requirements for HVAC equipment installed in new buildings in the State of California.

**1.03 SUBMITTALS**

- A. Submit drawings indicating components, dimensions, weights and loadings, required clearances, and location and size of field connections.
- B. Submit product data indicating rated capacities, weights, accessories, service clearances and electrical requirements.
- C. Submit manufacturer's installation instructions.

**1.04 OPERATION AND MAINTENANCE DATA**

- A. Submit operation and maintenance data.
- B. Include manufacturer's descriptive literature, start-up and operating instructions, installation instructions, and maintenance procedures.

**1.05 HANDLING**

- A. Comply with manufacturer's installation instructions for rigging, unloading, and transporting

units.

- B. Protect units from physical damage. Leave factory shipping covers in place until installation.

1.06 WARRANTY

- A. Provide a full parts warranty for one year from start-up or 18 months from shipment, whichever occurs first.
- B. Provide five year extended warranty for compressors including materials only.
- C. Provide five year limited warranty for heat exchanger including materials only.

1.07 REGULATORY REQUIREMENTS

- A. Unit shall conform to UL 1995/CSA 22.2 #236 for construction of packaged air conditioner and shall have UL/CSA label affixed to rooftop package.
  - 1. In the event the unit is not UL/CSA approved, the manufacturer shall, at his expense, provide for a field inspection by a UL/CSA representative to verify conformance to UL/CSA standards. If necessary, contractor shall perform required modifications to the unit to comply with UL/CSA, as directed by the UL/CSA representative, at no additional expense to the Owner.
- B. Gas-fired heating rooftop units shall conform to UL 795/Canadian Standards Association (CAN/CSA-3.2) for construction of packaged air conditioner.

1.08 SUMMARY

- A. The contractor shall furnish and install packaged rooftop air conditioning unit(s) as shown and as scheduled on the contract documents. The unit(s) shall be installed in accordance with this specification and perform at the conditions specified, scheduled or as shown on the contract drawings.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. GENERAL

- 1. Manufacturer of packaged unitary rooftop products shall have had a minimum of five years successful experience in the manufacture and service support of the rooftop packages specified herein. Manufacturers with less than five years experience in the production of rooftop units of the sizes and types specified shall not be acceptable.
- B. Base bid shall be Carrier packaged rooftop air conditioning units with approved alternate being Trane or York. Alternates must still comply with the performance and features as specified herein and as indicated on the design documents. Job will be awarded on basis of specified product. Substitutions must be selected and approved within 14 calendar days after award of contract.

2.02 GENERAL UNIT DESCRIPTION



- A. Unit(s) furnished and installed shall be cooling only packaged rooftops as specified on the contract documents and within these specifications. Cooling capacity ratings shall be based upon ARI Standard 360. Unit(s) shall consist of insulated weathertight casing with compressors, air cooled condenser coil, condenser fans, evaporator coil, filters, supply and/or exhaust fan motors and drives, and unit controls.
- B. Unit(s) shall be single piece construction as manufactured at the factory. Package units shall be constructed for installation on a roof curb providing full perimeter support under air handler section and pedestal support under condenser section.
- C. Unit(s) shall be factory run tested to include the operation of all fans, compressors, heat exchangers, and control sequences.
- D. Unit(s) shall have labels, decals, and/or tags to aid in the service of the unit and indicate caution areas.

#### 2.03 UNIT CASING

- A. Cabinet: Galvanized steel, phosphatized, and finished with an air-dry paint coating durable enough to withstand a minimum of 500 consecutive-hour salt spray application in accordance with standard ASTM B 117. Structural members shall be heavy gauge with access doors and removable panels of heavy gauge steel. Roof panels shall be sloped to provide positive drainage of rain water / melting snow away from the cabinet.
- B. Access Doors: Fully gasketed hinged doors with fluted knob fasteners and chained "tie-backs" to provide access to filters, heating section, return/exhaust air fan section, supply air fan section and evaporator coil section.
- C. Control Panel: The unit control panel section shall be compartmented to separate high and low voltage components. The control panels shall also be fully gasketed, hinged and provided with quick release latches for easy access.
- D. Insulation: Provide 1/2 inch thick coated fiberglass internal liner on all exterior panels in contact with the conditioned air stream.

#### 2.04 AIR FILTERS

- A. Air Filters: Filters shall mount integral within unit casing and be accessible via hinged access panels. Filters shall be two inch thick washable permanent wire mesh with metal frame.

#### 2.05 FANS - SUPPLY AND/OR EXHAUST

- A. Provide air foil supply and forward curved exhaust fans with fixed-pitch sheave drive assemblies. Dynamically balance all fans and the unit's running fan assembly (fan mounted on actual shaft, bearings and in scroll housing) to assure smooth operation of the fan and it's associated assembly. Balancing of the fan only shall not be acceptable.
- B. Mount fan motor(s) and fan(s) on a common base assembly and isolated from unit with double deflection rubber-in-shear isolators. Provide thrust restraint isolation on the fan housing/fan board to assure smooth fan startup transition and operation.
- C. Fan shaft shall be mounted on grease lubricated ball bearings.
- D. Motor shall be high efficiency. All drive components shall be accessible without the use of

scaffolds or ladders, to facilitate periodic maintenance checks and for operator safety. Fan capacity control shall be by variable frequency drive.

#### 2.06 GAS FIRED HEATING SECTION

- A. Provide gas-fired heating section as a completely assembled and factory-installed heating system integral to unit, UL or CSA approved specifically for outdoor applications for use downstream from refrigerant cooling coils. Provide capability for threaded gas piping connection through side or bottom of unit.
- B. Heating section shall be factory fire-tested prior to shipment.
- C. Gas Burner: Forced-draft type burner with adjustable combustion air supply, gas valve, manual shut-off, direct spark or pilot ignition, and flame sensing monitoring electrode. Provide air proving switch to prevent burner operation when burner is open for maintenance or inspection.
- D. Gas Burner Safety Controls: Provide electronic flame safety controls for the proving of combustion air prior to ignition sequence with pre-purge cycle, continuous electronic flame supervision, and sixty second delay between first and second stage gas valve operation on two-stage heaters.
- E. Combustion Blower: Provide centrifugal type fan with built-in thermal overload protection on fan motor.

#### 2.07 EVAPORATOR COIL SECTION

- A. Provide heavy duty aluminum fins mechanically bonded to copper tubes. Evaporator coil shall be inter-circuited to maintain active coil face area at part load conditions. Coil shall also utilize internally enhanced tubing for maximum efficiency.
- B. Provide a thermostatic expansion valve (TXV) for each refrigerant circuit. Factory pressure and leak test coil at 300 psi.
- C. Provide pitched stainless steel drain pan to assure positive drainage of condensate from the unit casing.

#### 2.08 CONDENSER SECTION

- A. Provide heavy duty aluminum fins mechanically bonded to copper tubes. Factory leak test coil under 450 psia pressure.
- B. Provide subcooling circuit(s) integral with condenser coils to maximize efficiency and prevent premature flashing of liquid refrigerant, to a gaseous state, ahead of the expansion valve.
- C. Provide vertical discharge, direct drive fans with steel blades, and three phase motors. Fans shall be statically and dynamically balanced. Motors shall be permanently lubricated, with built-in current and thermal overload protection and weathertight slinger over motor bearings.
- D. Furnish unit with factory-installed electronic low ambient option to allow for operation down to 0 degrees F.
- E. Provide factory-installed louvered steel coil guards around perimeter of condensing section

to protect the condenser coils, refrigerant piping and control components. Louvered panels shall be fabricated from heavy gauge galvanized steel and be rigid enough to provide permanent protection for shipping and pre-/post- installation. Course wire mesh is not an acceptable material for coil guards.

- F. Condenser coils shall be V-banked for cleaning ease. The coils shall not exceed 14 fins per inch density in order to permit routine cleaning, and prevent excessive air pressure drop across the condenser coil.

## 2.09 REFRIGERATION SYSTEM

- A. Compressor: shall be industrial grade, energy efficient direct drive 3600 RPM maximum speed reciprocating or scroll type. The motor shall be of a suction gas cooled hermetic design. Compressor shall have centrifugal oil pump with dirt separator, oil sight glass, and oil charging valve.
  - 1. If semi-hermetic reciprocating industrial grade compressors are utilized provide single piece crankshafts, connecting rods aluminum pistons, rings to prevent gas leakage, high strength non-flexing ring type suction and discharge valves, spring loaded heads, replaceable cylinder liners, and sealing service immersed in oil. Provide removable discharge heads and hand hole covers, and discharge service valves.
  - 2. Provide compressor with automatic capacity reduction equipment consisting of suction valve unloaders, Use electric solenoid actuated lifting mechanism operated by oil pressure. Provide for unloaded compressor start.
- B. Provide with thermostatic motor winding temperature control to protect against excessive motor temperatures resulting from over-/under-voltage or loss of charge. Provide high and low pressure cutouts, and reset relay.
- C. Provide coil frost protection compressor unloading based on refrigerant circuit suction temperature to prevent coil frosting with minimum energy usage. As an alternate, factory-installed hot gas bypass shall be required on all VAV units to prevent coil frosting.

## 2.10 EXHAUST/RETURN SECTION

- A. Provide 100% modulating exhaust air capabilities integral to unit. Unit shall control building pressurization by the operation of exhaust fans and modulation of discharge dampers. Controller shall compare actual building interior pressure with outside ambient air pressure and supply duct pressure. Pressurization setpoint shall be field adjustable at the human interface to positive, neutral or negative values.

## 2.11 OUTDOOR AIR SECTION

- A. Provide 100% modulating dry bulb temperature based economizer system fully integrated with unit return and exhaust air dampers. Unit operation is through primary temperature controls that automatically modulate dampers to maintain desired space temperature conditions.
  - 1. Provide automatic outdoor dry bulb temperature lockout sensor.
- B. Provide adjustable minimum position control through the standard rooftop Human Interface.

- C. Provide spring-return motor for outside air damper closure during unit shutdown or power interruption.

#### 2.12 DAMPERS

- A. Provide low leak dampers with a leakage rate not to exceed 2.5% of nominal airflow at one inch W.C. static pressure.
- B. Leakage rate shall be determined in accordance with AMCA Standard 575.

#### 2.13 DDC MICROPROCESSOR CONTROLS

- A. General - Each unit shall be provided with a factory-installed, programmed and run-tested, stand-alone, microprocessor control system suitable for CV or VAV control as required. This system shall consist of temperature and pressure (thermistor and transducer) sensors, printed circuit boards, and a unit-mounted Human Interface Panel. The microprocessor shall be equipped with on-board diagnostics to indicate that all hardware, software, and all interconnected wiring and sensors are in proper operating condition. The microprocessor's memory shall be non-volatile EEPROM type, thus requiring no battery or capacitive backup to maintain all data during a power loss.
- B. The Human Interface Panel shall be readily accessible for service diagnosis and programming without having to open the main control panel on the rooftop unit. Alphanumeric coded displays shall not be acceptable.
- C. Ventilation Override Module (VOM) - shall be provided which will allow the user to field reconfigure and establish up to five different purge, exhaust and building pressurization sequences. These sequences, factory prioritized, shall be reconfigurable through the Human Interface Panel at the rooftop unit, the Remote Human Interface or the TRACER building automation system.
- D. Anti-recycle Protection - shall be provided to prevent excessive cycling, and premature wear, of the compressors, contactors and related components.
- E. Airflow modulation shall be provided by a variable frequency inverter that is factory-mounted and functionally tested. Adjustable frequency inverter drive shall safely vary the speed of the fan motor allowing the motor to meet the dynamic requirements at the shaft of the motor meeting system static. Inverter frequency drive shall match the fan motor according to the motor's FLA rating. Inverter controller shall have a display that provides readout functions that include: output frequency, output voltage, output current, output power, DC bus voltage, interface terminal status, and fault status.

#### 2.15 BUILDING MANAGEMENT SYSTEM

- A. Provide factory mounted Tracer Building Automation System control interface to operate with the Tracer 100 Series building management system. Communication link shall use a two-wire twisted pair.
- B. Control Functions: Includes unit time scheduling, occupied/unoccupied mode, optimal start/stop, night-time free-cooling purge mode, two-step demand limiting, night setback, morning warmup, discharge air set point adjustment, universal smoke purge, building pressurization, timed override and alarm shutdown.
- C. BAS control shall permit auto reset of latching diagnostics.

- D. Equipment shall be furnished with RS-232 or RS0485 BACnet interface.

2.17 ROOF CURB

- A. Provide factory supplied roof curb, heavy gauge zinc coated steel with supply and return air gasketing. Ship knocked down and provide instructions for easy assembly.
- B. Curb shall be manufactured in accordance with the National Roofing Contractors Association guidelines for rooftop equipment support.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that roof is ready to receive work and opening dimensions are as indicated on shop drawings.
- B. Verify that proper power supply is available.

3.02 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Mount units on factory built roof mounting frame providing watertight enclosure to protect ductwork. Install roof mounting curb level.

3.03 MANUFACTURER'S FIELD SERVICES

- A. The manufacturer shall furnish complete submittal wiring diagrams of the package unit as applicable for field maintenance and service.

**END OF SECTION**



**SECTION 25 0000**  
**BUILDING SYSTEMS CONTROLS**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Products Furnished But Not Installed Under This Section
- B. Description
- C. Approved Control System Contractor
- D. Quality Assurance
- E. System Performance
- F. Submittals
- G. Warranty
- H. Ownership of Proprietary Material

1.02 RELATED SECTIONS

- A. The General Conditions of the Contract, Supplementary Conditions, and General Requirements are a part of these Specifications and shall be used in conjunction with this Section as a part of the Contract Documents. Consult them for further instructions pertaining to this work.

1.03 DESCRIPTION

- A. General: The control system shall be as indicated on the drawings and described in the specifications.
- B. Direct Digital Control (DDC) technology shall be used to provide the functions necessary for control of mechanical systems on this project.
- C. The control system shall accommodate simultaneous multiple user operation. Access to the control system data should be limited only by operator password. Multiple users shall have access to all valid system data. An operator shall be able to log onto any work-station on the control system and have access to all appropriate data.
- D. The control system shall be designed such that each mechanical system will be able to operate under stand-alone control. As such, in the event of a network communication failure, or the loss of any other controller, the control system shall continue to independently operate under control.
- E. Communication between the control panels and all work-stations shall be over a high speed network. All nodes on this network shall be peers. The operator shall not have to know the panel identifier or location to view or control an object. Application Specific Controllers shall be constantly scanned by the network controllers to update point information and alarm information.

#### 1.04 APPROVED CONTROL SYSTEM CONTRACTOR

A. Approved Control System Contractor:

The Trane Company  
Johnson Controls  
Siemens  
Carrier Controls

#### 1.05 QUALITY ASSURANCE

A. System Installer Qualifications

1. The Installer shall have an established working relationship with the Control System Manufacturer of not less than three years.
2. The Installer shall have successfully completed Control System Manufacturer's classes on the control system. The Installer shall present for review the certification of completed training, including the hours of instruction and course outlines upon request.
3. The installer shall have an office within 50 miles of the project site and provide 24 hour response in the event of a customer call.

B. Codes and Standards: Meet requirements of all applicable standards and codes, except when more detailed or stringent requirements are indicated by the Contract Documents, including requirements of this Section.

1. Underwriters Laboratories: Products shall be UL-916-PAZX listed.
2. National Electrical Code -- NFPA 70.
3. Federal Communications Commission -- Part J.
4. ASHRAE/ANSI 135-1995 (BACnet)
5. Pikes Peak Regional Building Code.

C. All products used in this installation shall be new, currently under manufacture, and shall be applied in similar installations for a minimum of 2 years.

D. Spare parts shall be available for at least 5 years after completion of this contract.

#### 1.06 SUBMITTALS

A. Contractor shall provide shop drawings and manufacturers' standard specification data sheets on all hardware and software to be provided. No work may begin on any segment of this project until submittals have been reviewed by the Engineer and Owner for conformity with the plan and specifications. Six (6) copies are required. All shop drawings shall be done on AutoCAD, and provided to the Owner on a compact disk.

B. Project Record Documents: Upon completion of installation submit three (3) copies of record (as-built) documents. The documents shall be submitted for approval prior to final completion and include:



1. Testing and Commissioning Reports and Checklists.
  2. Operating and Maintenance (O & M) Manual - These shall be as-built versions of the submittal product data.
- C. Training Manuals: The Contractor shall provide a course outline and training manuals for all training classes at least six weeks prior to the first class. The Owner reserves the right to modify any or all of the training course outline and training materials. Review and approval by Owner and Engineer and shall be completed at least 3 weeks prior to first class.

#### 1.07 WARRANTY

- A. Warrant all work as follows:
1. Labor & materials for control system specified shall be warranted free from defects for a period of twelve (12) months after final completion acceptance by the Owner. Control System failures during the warranty period shall be adjusted, repaired, or replaced at no charge or reduction in service to the Owner. The Contractor shall respond to the Owner's request for warranty service within 24 hours during customary business hours.

#### 1.08 OWNERSHIP OF PROPRIETARY MATERIAL

- A. All project developed hardware and software shall become the property of the Owner. These include but are not limited to:
1. Project graphic images
  2. Record drawings
  3. Project database
  4. Job-specific application programming code
  5. All documentation.

### PART 2 PRODUCTS

#### 2.01 SECTION INCLUDES

- A. Acceptable Manufacturers
- B. Operator Interface
- C. System Software
- D. Building Controllers
- E. Custom Application Controllers
- F. Application Specific Controllers
- G. Communications

## H. Input/Output Interface

### I. Auxiliary Control Devices

## 2.02 ACCEPTABLE MANUFACTURERS

### A. Acceptable systems are:

#### CONTROL SYSTEM MANUFACTURER

The Trane Company  
Johnson Controls  
Siemens  
Carrier Controls

### B. The Contractor shall use only listed manufacturers products as shown in section 1 of this division. When a product or component is referred to by manufacturer's name and/or model number, the Contractor shall use only that product.

## 2.03 OPERATOR INTERFACE

### A. Operator Interface. Furnish 1 PC based work-stations as shown on the system drawings. Each of these work-stations shall be able to access all information in the system. These work-stations shall reside on the same high speed network as the building controllers, and also be able to dial into the system.

### B. Hardware. Each operator work-station shall consist of the following:

1. Personal Computer. Furnish IBM compatible PCs as shown on the drawings. The operator's PC shall have a minimum capability of the following:
  - a. The CPU shall be a minimum of an Intel Pentium and operate at a minimum of 3 GHz.
  - b. A minimum of 2.0 Gigabytes of RAM.
  - c. 16X CD R/W drive.
  - d. 80 Gigabyte hard disk with a minimum access time of 12 milliseconds shall be provided.
  - e. A three button mouse will also be provided.
  - f. A 17" LCD monitor.
  - g. Furnish all required serial, parallel, USB2.0, and network communication ports, and all cables for proper system operation.
2. Modems. Furnish auto-dial telephone modems and associated cables as required for communication to remote buildings, and work stations. The modem shall transmit at a minimum of 14400 baud, and communicate over voice-grade telephone lines.
3. Printers. Each work station shall have 1 ink jet printers.
4. BACnet. The PCWS shall use the Read (Initiate) and Write (Execute) Services as defined in Clauses 15.5 and 15.8, respectively, of ASHRAE Standard 135-95, to communicate with BACnet objects in the internetwork. Objects supported shall include: Analog input, analog output, analog value, binary input, binary output, binary value, device.

C. System Software

1. Operating System. Furnish a commercially available, concurrent multi-tasking operating system. The operating system shall also support the use of other common software applications that operate under current version of Microsoft Windows. Acceptable operating systems are Windows XP or newer.
2. System Graphics. The Operator Work-station software shall be graphically oriented. The system shall allow display of up to 10 graphic screens at once for comparison and monitoring of system status. Provide a method for the operator to easily move between graphic displays and change the size and location of graphic displays on the screen. The system graphics shall be able to be modified while on line. An operator with the proper password level shall be able to add, delete, or change dynamic points on a graphic. Dynamic points shall include analog and binary values, dynamic text, static text, and animation files. Graphics shall have the ability to show animation of equipment.
  - a. Custom Graphics. Custom graphic files shall be created with the use of commonly available graphics packages such as PC Paint. The graphics generation package shall create and modify graphics that are saved in industry standard formats such as PCX, BMP, GIF and JPEG. The graphics generation package shall also provide the capability of capturing or converting graphics from other programs such as Designer, or AutoCAD.
  - b. Graphics Library. Furnish a complete library of standard HVAC equipment such as chillers, boilers, air handlers, terminals, fan coils, and unit ventilators. This library shall also include standard symbols for other equipment including fans, pumps, coils, valves, piping, dampers, and duct-work. The library shall be furnished in a file format compatible with the graphics generation package program.
  - c. Engineering Units. Allow for selection of the desired engineering units (i.e. Inch pound or SI) in the system. Unit selection shall be able to be customized by locality to select the desired units for each measurement. Engineering units on this project shall be: Inch-Pound

D. System Applications. Each work-station shall provide operator interface and off-line storage of system information. Provide the following applications at each work-station.

1. Automatic System Database Save and Restore. Each work-station shall store on the hard disk a copy of the current database of each building controller. This database shall be updated whenever a change is made in any panel in the system. The storage of this data shall be automatic and not require operator intervention. In the event of a database loss in a building management panel, the first work-station to detect the loss shall automatically restore the database for that panel.
2. Manual Database Save and Restore. A system operator with the proper password clearance shall be able to archive the database from any system panel and store on magnetic media. The operator shall also be able to clear a panel database and manually initiate a download of a specified database to any panel in the system.
3. System Configuration. The work-station software shall provide a graphical method of configuring the system. The user with proper security shall be able to add new devices, and assign modems to devices. This shall allow for future system changes or additions.
4. On-Line Help. Provide a context sensitive, on line help system to assist the operator

in operation and editing of the system. On line help shall be available for all applications and shall provide the relevant data for that particular screen. Additional help information shall be available through the use of hypertext.

5. Security. Each operator shall be required to log on to the system with a user name and password in order to view, edit, add, or delete data. System security shall be selectable for each operator. The system supervisor shall have the ability to set passwords and security levels for all other operators. Each operator password shall be able to restrict the operators access for viewing and/or changing each system application, full screen editor, and object. Each operator shall automatically be logged off of the system if no keyboard or mouse activity is detected. This auto logoff time shall be set per operator password. All system security data shall be stored in an encrypted format.
6. System Diagnostics. The system shall automatically monitor the operation of all work-stations, printers, modems, network connections, building management panels, and controllers. The failure of any device shall be annunciated to the operator.
7. Alarm Processing. Any object in the system shall be configurable to alarm in and out of normal state. The operator shall be able to configure the alarm limits, warning limits, states, and reactions for each object in the system.
  - a. Alarm Reactions. The operator shall be able to determine what actions, if any, are to be taken, by object (or point), during an alarm. Actions shall include logging, printing, starting programs, displaying messages, dialing out to remote stations, paging, providing audible annunciation or displaying specific system graphics. Each of these actions shall be configurable by work-station and time of day. An object in alarm that has not been acknowledged within an operator specified time period shall be re-routed to an alternate operator specified alarm receipt device.
8. Trend Logs. The operator shall be able to define a custom trend log for any data in the system. This definition shall include interval, start-time, and stop-time. Trend intervals of 1, 5, 15, 30, and 60 minutes as well as once a shift (8 hours), once a day, once a week, and once a month shall be selectable. All trends shall start based on the hour. Each trend shall accommodate up to 64 system objects. The system operator with proper password shall be able to determine how many samples are stored in each trend. Trend data shall be sampled and stored on the Building Controller panel and be archived on the hard disk. Trend data shall be able to be viewed and printed from the operator interface software. Trends must be viewable in a text based format or graphically. They shall also be storable in a tab delimited ASCII format for use by other industry standard word processing and spreadsheet packages.
9. Dynamic Graphical Charting. The operator shall be able to select any system point value for charting in real time.
  - a. Up to four values at one time shall be selectable for each chart.
  - b. The type of chart (bar, line, 3-D, etc.) shall be selectable.
10. Alarm and Event Log. The operator shall be able to view all logged system alarms and events from any location in the system. Events shall be listed chronologically. An operator with the proper security level may acknowledge and clear alarms. All that have not been cleared by the operator shall be archived to the hard disk on the

work-station.

11. Object and Property Status and Control. Provide a method for the operator with proper password protection to view, and edit if applicable, the status of any object and property in the system. These statuses shall be available by menu, on graphics, or through custom programs.
  12. Clock Synchronization. The real time clocks in all building control panels and work-stations shall be synchronized on command of an operator. The system shall also be able to automatically synchronize all system clocks, daily from any operator designated device in the system. The system shall automatically adjust for daylight savings and standard time if applicable.
  13. Reports and Logs. Provide a reporting package that allows the operator to select, modify, or create reports. Each report shall be definable as to data content, format, interval, and date. Report data shall be archived on the hard disk for historical reporting. Provide the ability for the operator to obtain real time logs of designated lists of objects. Reports and logs shall be stored on the PC hard disk in a format that is readily accessible by other standard software applications including spreadsheets and word processing. Reports and logs shall be readily printed to the system printer. The operator shall be able to designate reports that shall be printed or stored to disk at selectable intervals.
    - a. Custom Reports: Provide the capability for the operator to easily define any system data into a daily, weekly, monthly, or annual report. These reports shall be time and date stamped and shall contain a report title and the name of the facility.
- E. Work-station Applications Editors. Each PC work-station shall support full screen editing of all system applications. Provide editors for each application at the PC work-station. The applications shall be downloaded and executed at the appropriate controller panels.
1. Controller. Provide a full screen editor for each type controller and application, that shall allow the operator with proper password to view and change the configuration, name, control parameters, and system set-points.
  2. Scheduling. An editor for the scheduling application shall be provided at each work-station. Provide a monthly calendar for each schedule. Exception schedules and holidays shall be shown clearly on the calendar. Provide a method for allowing several related objects to follow a schedule. The advance and delay time for each object shall be adjustable from this master schedule.
  3. Air System Equipment Coordination. Provide a full screen editor that allows equipment to be grouped for proper operation as specified in the sequence of operations. This shall include the coordination of VAV boxes with their associated Air Handling Equipment.
  4. Chiller System - The chiller plant control application shall be configured using a full screen editor and shall provide operating status for the system. The display shall include:
    - a. System mode of the chiller plant
    - b. Chiller enable/disable status
    - c. System supply water setpoint
    - d. System supply and return water temperature

- e. System Chilled water pump status
  - f. System Chilled water flow
  - g. Bypass pipe flow rate (if applicable)
  - h. Current chiller plant control operation
  - i. Add information
  - j. Subtract information
  - k. System failure information
  - l. Chiller failure information
  - m. Rotation information
  - n. Override capabilities to force an add control, subtract control, or change of sequence.
  - o. Remove a chiller from a sequence temporarily for service purposes.
5. Custom Application Programming. Provide the tools to create, modify, and debug custom application programming. The operator shall be able to create, edit, and download custom programs at the same time that all other system applications are operating. The system shall be fully operable while custom routines are edited, compiled, and downloaded. The programming language shall have the following features:
- F. Portable Operator's Terminal. Furnish a Portable Operator's Terminal that shall be capable of accessing all system data. This device may be connected to any point on the system inter-network or may be connected directly to any controller for programming, set-up, and troubleshooting. BACnet. The Portable Operators Terminal shall use the Read (Initiate) and Write (Execute) Services as defined in Clauses 15.5 and 15.8, respectively, of ASHRAE Standard 135-95, to communicate with BACnet objects in the internetwork. Objects supported shall include: Analog input, analog output, analog value, binary input, binary output, binary value, device.
- 1. The Portable Operator's Terminal shall be an IBM compatible notebook-style PC including all software and hardware required. The PC shall contain at minimum:
    - a. 266 MHz Intel Pentium Processor
    - b. 32 MB RAM
    - c. 2 Gigabyte Hard Drive
    - d. 3.5" 1.44 MB Floppy Disk Drive
    - e. 16X CD-ROM Drive

## 2.04 SYSTEM SOFTWARE

- A. System Security
- 1. User access shall be secured using individual security passwords and user names.
  - 2. Passwords shall restrict the user to only the objects, applications, and system functions as assigned by the system manager.
  - 3. User logon/logoff attempts shall be recorded.
- B. Scheduling. Provide the capability to schedule each object or group of objects in the system. Each of these schedules shall include the capability for start, stop, optimal start, optimal stop, and night economizer actions. Each schedule may consist of up to ten (10) events. When a group of objects are scheduled together, provide the capability to define advances and delays for each member. Each schedule shall consist of the following:

1. Weekly Schedule
  2. Exception Schedules
  3. Holiday Schedules
  4. Optimal Start/Stop
- C. Alarm Reporting. The operator shall be able to determine the action to be taken in the event of an alarm. Alarms shall be routed to the appropriate work-stations based on time and other conditions. An alarm shall be able to start programs, be logged in the event log, printed, generate custom messages graphics.
- D. Remote Communications. The system shall have the ability to dial out in the event of an alarm. Receivers shall include PC Workstations, and Alpha-numeric pagers. The alarm message shall include the name of the calling location, the device that generated the alarm, and the alarm message itself. The operator shall be able to remotely access and operate the system using dial up communications in the same format and method used on site under section 2.1 (Operator Interface).
- E. Chiller Sequencing: Provide applications software to properly sequence the chiller plant to minimize energy use. This application shall perform the following functions:
1. The chiller plant control application shall have the ability to control a maximum of 25 chillers of any type including centrifugal, helirotor, scroll, reciprocating and absorption machines as detailed in the sequence of operations.
  2. This application shall be able to control both constant and variable flow systems as well as parallel, series and decoupled piping configurations.
  3. The chiller plant control application shall be able to control multiple chiller plants per site.
  4. Diagnostics/Protection - The chiller plant application program shall be able to integrate individual chiller diagnostics into control action decisions.
  5. Event Processing - All chiller plant control and status events shall be recorded, at the operator's selection, in the building management system event log to facilitate troubleshooting.
  6. Alarm Indications - The chiller plant control status screens shall display chiller plant and individual chiller alarm messages.
- F. PID Control. A PID (proportional-integral-derivative) algorithm with direct or reverse action and anti-wind-up shall be supplied. The algorithm shall calculate a time-varying analog value used to position an output or stage a series of outputs. The controlled variable, set-point, and PID gains shall be user-selectable. The set-point shall optionally be chosen to be a reset schedule.
- G. Staggered Start. This application shall prevent all controlled equipment from simultaneously restarting after a power outage. The order in which equipment (or groups of equipment) is started, along with the time delay between starts shall be user-selectable.
- H. System Calculations. Provide software to allow instantaneous power (e.g. KW), flow rates (e.g. L/s [GPM]) to be accumulated and converted to energy usage data. Provide an

algorithm that calculates a sliding-window KW demand value. Provide an algorithm that calculates energy usage and weather data (heating and cooling degree days). These items shall all be available for daily, previous day, monthly and the previous month.

- I. Anti-Short Cycling. All binary output points shall be protected from short cycling. This feature shall allow minimum on-time and off-time to be selected.

## 2.05 BUILDING CONTROLLERS

- A. General. Provide Building Controllers to provide the performance specified in section 1 of this division. Each of these panels shall meet the following requirements.
  - 1. The Building Automation System shall be composed of one or more independent, stand-alone, microprocessor based Building Controllers to manage the global strategies described in System software section.
  - 2. The controller shall provide a communications port for connection of the Portable Operators Terminal using Point to Point BACnet physical/data link layer protocol or a connection to the inter-network.
  - 3. The operating system of the Controller shall manage the input and output communications signals to allow distributed controllers to share real and virtual point information and allow central monitoring and alarms.
  - 4. BACnet. The Building Controller shall use the Read (Initiate) and Write (Execute) Services as defined in Clauses 15.5 and 15.8, respectively, of ASHRAE Standard 135-95, to communicate with BACnet objects in the internetwork. Objects supported shall include: Analog input, analog output, binary input, binary output, device.
- B. Communications. Each Building Controller shall reside on a BACnet inter-network using the ISO 8802-3 (Ethernet) or ARCNET (ASTM 878.1) Physical/Data Link layer protocol. Each Building Controller shall also perform routing to a network of Custom Application and Application Specific Controllers.
- C. Memory. The Building Controller shall maintain all BIOS and programming information in the event of a power loss for at least 72 hours.

## 2.06 CUSTOM APPLICATION CONTROLLERS

- A. General. Provide Custom Application Controllers to provide the performance specified in section 1 of this division. Each of these panels shall meet the following requirements.
  - 1. The Building Automation System shall be composed of one or more independent, stand-alone, microprocessor based Building Controllers to manage the local strategies described in System software section.
  - 2. The operating system of the Controller shall manage the input and output communications signals to allow distributed controllers to share real and virtual point information and allow central monitoring and alarms.
- B. Controller hardware shall be suitable for the anticipated ambient conditions.
  - 1. Controllers used outdoors and/or in wet ambient shall be mounted within NEMA 4 Type waterproof enclosures, and shall be rated for operation at -40 C to 65 C (- 40 F to 150 F).



2. Controller used in conditioned ambient shall be mounted in NEMA 1 Type rated enclosures, and shall be rated for operation at 0 C to 50 C (32 F to 120 F).

## 2.07 APPLICATION SPECIFIC CONTROLLERS

- A. General. Application specific controllers (ASC) are microprocessor-based DDC controllers which through hardware or firmware design are dedicated to control a specific piece of equipment. They are not fully user programmable, but are customized for operation within the confines of the equipment they are designed to serve.
  1. Each ASC shall be capable of stand-alone operation and shall continue to provide control functions without being connected to the network.
  2. Each ASC will contain sufficient I/O capacity to control the target system.
- B. Environment. The hardware shall be suitable for the anticipated ambient conditions.
  1. Controllers used outdoors and/or in wet ambient shall be mounted within NEMA 4 Type waterproof enclosures, and shall be rated for operation at -40 C to 65 C (- 40 F to 150 F).
  2. Controller used in conditioned ambient shall be mounted in NEMA 1 Type rated enclosures, and shall be rated for operation at 0 C to 50 C (32 F to 120 F).

## 2.08 COMMUNICATIONS

- A. This project shall comprise a BACnet inter-network. All PC Workstations and Building Controller components shall meet ASHRAE / ANSI Standard 135-1995, BACnet.
- B. Each BACnet device shall operate on the BACnet physical/data link protocols specified for that device as defined earlier in this section
- C. The controls Contractor shall provide all communication media, connectors, repeaters, hubs, and routers necessary for the inter-network.
- D. All Building Controllers shall have a communications port for connections with the operator interfaces. This may be either an RS-232 port for Point to Point connection or a network interface node for connection to the Ethernet or ARCNET network.
- E. Remote operator interface via a 9600 or faster baud modem shall allow for communication with any and all controllers on this network as described in the following section.
- F. Communications services over the internetwork shall result in operator interface and value passing that is transparent to the internetwork architecture.

## PART 3 EXECUTION

### 3.01 GENERAL WORKMANSHIP

- A. Install equipment, piping, wiring/conduit parallel to building lines (i.e. horizontal, vertical, and parallel to walls) wherever possible.
- B. Provide sufficient slack and flexible connections to allow for vibration of piping and equipment.

- C. Install all equipment in readily accessible location as defined by chapter 1 article 100 part A of the NEC. Control panels shall be attached to structural walls unless mounted in equipment enclosure specifically designed for that purpose. Panels shall be mounted to allow for unobstructed access for service.
- D. Verify integrity of all wiring to ensure continuity and freedom from shorts and grounds.
- E. All equipment, installation, and wiring shall comply with acceptable industry specifications and standards for performance, reliability, and compatibility and be executed in strict adherence to local codes and standard practices.
- F.

#### PART 4 SEQUENCE OF OPERATIONS

##### 4.01 SINGLE DUCT VAV TERMINAL UNITS WITH DDC CONTROLS

- A. Single Duct VAV Terminals, Cooling Only - On a rise in space temperature, the unit will modulate to provide maximum CFM. As space temperature decreases, the box will modulate down to its minimum CFM.
- B. Single Duct VAV Terminals With Reheat - On a rise in temperature above the cooling setpoint, the VAV terminal unit shall modulate to its maximum CFM. As the space temperature drops below the cooling setpoint, the terminal unit shall modulate to its minimum CFM. As the space temperature continues to fall to the heating setpoint, the terminal shall modulate to its heating minimum CFM. At this point, the heat will be staged on as follows:
  - 1. Staged Electric - Stage on electric heat with a 1 degree interval per stage.

##### 4.02 PARALLEL FAN POWERED TERMINAL UNITS WITH DDC CONTROLS

- A. Occupied Cycle
  - 1. Intermittent Fan Control - As the space temperature falls below cooling setpoint, the terminal unit shall modulate to its minimum cooling CFM. Upon a continued drop in temperature and/or unit CFM, the parallel fan will be energized. Upon a further decrease in space temperature, the terminal unit will modulate to heating minimum CFM. The heating will then be staged on as follows:
    - a. Staged Electric - Stage on electric heat with a 1 degree interval per stage.
- B. Unoccupied Cycle
  - 1. The air valve shall drive closed. The fan and heat shall cycle to maintain a reduced space temperature.

##### 4.03 PACKAGED ROOFTOP AIR CONDITIONING UNIT

- A. Each Commercial Rooftop Unit shall have a microprocessor- based controller which shall monitor and control the commercial rooftop unit in a stand-alone mode or as directed by the building automation system. The rooftop control panel shall have a human interface panel with a 2-line by 40-character clear English LCD display and a 16 button keypad for monitoring, setting, editing and controlling.

- B. The building automation system (BAS) shall perform the following rooftop control strategies, provide the points listed on the point list and provide the specified monitoring and diagnostics.
1. Unoccupied Mode - When the BAS initiates the Unoccupied mode, the rooftop shall assume the unoccupied heating and cooling setpoints. If the unoccupied setpoints are exceeded, the unit shall heat or cool until the zone temperature is within the unoccupied setpoints.
    - a. Night Setback Temperature Control - During unoccupied hours, the rooftop unit shall be controlled by the BAS to maintain user-defined unoccupied heating and cooling setpoints. The outdoor air damper shall remain closed for night setback operation (unless economizing for zone cooling). The fan shall operate in the automatic control mode.
    - b. Purge/Night Economizer - The purge mode shall turn on the fan and enable the economizer during unoccupied hours to cool a zone using cool night outdoor air. Through the BAS Time of Day Scheduling, the operator shall specify when the purge mode occurs. During the purge mode, the economizer shall be enabled while mechanical outdoor cooling and heating are disabled.
  2. Transition from Unoccupied to Occupied - When the unit transitions from the unoccupied operation to occupied operation, start-up or morning warm-up mode shall be activated.
    - a. Startup Mode - The rooftop unit can be controlled to the Startup mode by the BAS for Optimal Start purposes. During the Startup mode, heating and cooling are enabled for the Rooftop. On Variable Air Volume units, the transition from the Unoccupied to the Startup mode may initiate the Morning Warmup mode, if the space temperature is below the Morning Warmup setpoint. On both Constant Volume and Variable Air Volume units, the outdoor air damper shall remain closed, unless economizing, until the zone's scheduled occupied time.
    - b. Morning Warmup (CV and VAV Units) - When the Rooftop shall change from the Unoccupied to the Occupied mode, the unit may enter the Morning Warmup mode. The Morning Warmup mode shall be initiated if the Morning Warmup sensor value is less than the Morning Warmup setpoint. The economizer (if supplied) shall be kept closed and the selected zone is heated. The BAS shall send the rooftop unit a Morning Warmup temperature and setpoint. The Morning Warmup setpoint shall be based on one specific zone designated by the operator or based on an average zone temperature.
  3. Occupied Operation - When the rooftop unit is controlled to the Occupied mode, all rooftop unit functions shall be enabled. Variable Air Volume units shall operate in supply air temperature control mode, and Constant Volume units shall operate under zone temperature control. The rooftop unit shall default to this mode in the event that communications with the BAS are lost.
    - a. Cooling/Economizer - During the Occupied cooling mode of operation the economizer, if available, and mechanical cooling are used to control the supply air temperature. If the enthalpy of the outdoor air is appropriate to use free cooling the economizer shall be used to satisfy the supply air setpoint. If more cooling is then required, compressors shall be staged on as necessary. Minimum On/Off timing of the compressors shall prevent rapid cycling. If the unit does not include an economizer, mechanical cooling only shall be used to satisfy cooling requirements. At outdoor air conditions above the enthalpy

- control setting, mechanical cooling only shall be used and the fresh air dampers shall remain at minimum position.
- b. Supply Air Setpoint (Variable Air Volume Units) - The supply air setpoint for each rooftop unit shall be defined by the user at the BAS or reset automatically based on an outdoor air or zone temperature.
  4. Daytime Warmup (VAV Units) - When the zone temperature drops below an operator-specified Daytime Warmup setpoint, the rooftop shall enter the Daytime Warmup mode. In this mode, the rooftop shall supply heat to the VAV boxes by driving the VAV boxes fully open and the inlet guide vanes or variable frequency drive(s) are driving to 100 percent. After the zone is warmed up, the unit shall resume normal cooling. The BAS shall communicate the Daytime Warmup temperature value for the Rooftop to use to initiate the necessary heating for the zone.
  5. Economizer Control (CV and VAV Units) - The BAS shall override the economizer controller on the rooftop unit to provide free cooling. If poor outdoor air conditions exist, the BAS shall lockout all economizers. On constant volume units the BAS shall also set the minimum economizer position to maintain a minimum outdoor air flow (cfm). On VAV units, as the supply fan modulates down, the minimum economizer position shall also be reset to compensate for the reduction in total airflow.
  7. Demand Limit - The BAS will automatically turn off loads when it predicts that electrical demand will exceed specified limits. The operator can assign priority for each load to be turned off. The capacity can be reduced to 50% or zero mechanical cooling or heating. Ventilation can be set up as Enabled or Disabled in the Demand Limit mode. For constant volume units, the fan can be set up as On or Auto. The BAS can also apply setpoint offsets to the current heating and cooling setpoints for constant volume units during the Demand Limit mode.
  8. Ventilation Override - The operator shall be able to customize up to five different override sequences to provide ventilation override control. The BAS control of the ventilation override mode shall be used to coordinate the entire HVAC system in response to system ventilation requests. If more than one ventilation override sequence is requested, the sequence with the highest priority shall be initiated by the rooftop unit control.
  9. Timed Override - When a Timed Override is initiated by the user, the rooftop unit shall return to its normal occupied mode for a period of time as specified at the BAS. When the Timed Override period has ended, the unit shall automatically return to its unoccupied cycle. The BAS shall monitor and store the override time for each Timed Override input for documentation of after-hours operation. The BAS shall also recognize a Timed Override function if provided.
  10. Coastdown Mode - Before the Rooftop unit is controlled to the Unoccupied mode, the BAS shall initiate the Coastdown or Optimal Stop mode. During the Optimal Stop mode, the supply fan shall remain on, the outdoor air damper shall remain open for ventilation, and the mechanical cooling and heating shall be disabled. The unit shall remain in the Coastdown mode until the scheduled Unoccupied time. The BAS shall turn equipment off as early as possible before the unoccupied time to reduce energy consumption, while still maintaining comfort in the zone.
  11. Shutdown - The BAS Priority Control program shall be able to put the zone in either the Shutdown or Occupied mode. All units which are members of that zone shall be immediately put in the Shutdown or Occupied mode. In the Shutdown mode, the unit

shall turn off as rapidly as possible with all cooling and heating disabled, and the outdoor air damper shall be closed.

12. Supply Air Pressure Control (VAV Units) - The BAS shall send supply air pressure setpoints to the rooftop to modulate the Inlet Guide Vanes or Variable Frequency Drive(s) based on the static pressure sensor located in the supply air duct. The BAS shall also read the status on the supply air sensor and display the pressure reading on the status screen.
- C. Diagnostics - The BAS system shall be able to alarm from all sensed points from the rooftop units and diagnostic alarms sensed by the unit controller. Alarm limits shall be designated for all sensed points.
1. Individual rooftop diagnostic and alarm statuses shall include the following latching items for each rooftop unit:
    - a. Emergency stop
    - b. Supply fan failure
    - c. Exhaust fan failure
    - d. Compressor trip (each circuit)
    - e. Freezestat Trip
    - f. Manual supply air static pressure limit
    - g. Compressor contactor fail (each circuit)

**END OF SECTION**



## SECTION 26 0519

### LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

#### PART 1 GENERAL

##### 1.01 SECTION INCLUDES

- A. Single conductor building wire.
- B. Service entrance cable.
- C. Metal-clad cable.
- D. Manufactured wiring systems.
- E. Wiring connectors.
- F. Electrical tape.
- G. Oxide inhibiting compound.
- H. Wire pulling lubricant.
- I. Cable ties.

##### 1.02 RELATED REQUIREMENTS

- A. Section 07 8400 - Firestopping.
- B. Section 26 0526 - Grounding and Bonding for Electrical Systems: Additional requirements for grounding conductors and grounding connectors.
- C. Section 26 0536 - Cable Trays for Electrical Systems: Additional installation requirements for cables installed in cable tray systems.
- D. Section 26 2100 - Low-Voltage Electrical Service Entrance: Additional requirements for electrical service conductors.

##### 1.03 QUALITY ASSURANCE

- A. Conform to requirements of NFPA 70.
- B. Maintain at the project site a copy of each referenced document that prescribes execution requirements.
- C. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience.
- D. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

##### 1.04 DELIVERY, STORAGE, AND HANDLING

- A. Receive, inspect, handle, and store conductors and cables in accordance with manufacturer's instructions.

##### 1.05 FIELD CONDITIONS

- A. Do not install or otherwise handle thermoplastic-insulated conductors at temperatures lower than 14 degrees F, unless otherwise permitted by manufacturer's instructions. When installation below this temperature is unavoidable, notify Architect and obtain direction before proceeding with work.

#### PART 2 PRODUCTS

##### 2.01 CONDUCTOR AND CABLE APPLICATIONS

- A. Do not use conductors and cables for applications other than as permitted by NFPA 70 and product listing.
- B. Provide single conductor building wire installed in suitable raceway unless otherwise indicated, permitted, or required.

1. Exceptions:
  - a. Use manufactured wiring systems for branch circuits where concealed under raised floors.

C. Nonmetallic-sheathed cable is not permitted.

## 2.02 CONDUCTOR AND CABLE GENERAL REQUIREMENTS

- A. Provide products that comply with requirements of NFPA 70.
- B. Provide products listed, classified, and labeled as suitable for the purpose intended.
- C. Unless specifically indicated to be excluded, provide all required conduit, boxes, wiring, connectors, etc. as required for a complete operating system.
- D. Comply with NEMA WC 70.
- E. Thermoplastic-Insulated Conductors and Cables: Listed and labeled as complying with UL 83.
- F. Thermoset-Insulated Conductors and Cables: Listed and labeled as complying with UL 44.
- G. Conductors for Grounding and Bonding: Also comply with Section 26 0526.
- H. Conductors and Cables Installed in Cable Tray: Listed and labeled as suitable for cable tray use.
- I. Conductors and Cables Installed Where Exposed to Direct Rays of Sun: Listed and labeled as sunlight resistant.
- J. Conductors and Cables Installed Exposed in Spaces Used for Environmental Air (only where specifically permitted): Plenum rated, listed and labeled as suitable for use in return air plenums.
- K. Conductor Material:
  1. Provide copper conductors except where aluminum conductors are specifically indicated or permitted for substitution. Conductor sizes indicated are based on copper unless specifically indicated as aluminum. Conductors designated with the abbreviation "AL" indicate aluminum.
    - a. Where aluminum conductors are substituted for copper, comply with the following:
      - 1) Size aluminum conductors to provide, when compared to copper sizes indicated, equivalent or greater ampacity and equivalent or less voltage drop.
      - 2) Increase size of raceways, boxes, wiring gutters, enclosures, etc. as required to accommodate aluminum conductors.
  2. Copper Conductors: Soft drawn annealed, 98 percent conductivity, uncoated copper conductors complying with ASTM B3, ASTM B8, or ASTM B787/B787M unless otherwise indicated.
  3. Tinned Copper Conductors: Comply with ASTM B33.
  4. Aluminum Conductors (only where specifically indicated or permitted for substitution): AA-8000 series aluminum alloy conductors recognized by ASTM B800 and compact stranded in accordance with ASTM B801 unless otherwise indicated.
- L. Minimum Conductor Size:
  1. Branch Circuits: 12 AWG.
- M. Conductor Color Coding:
  1. Color code conductors as indicated unless otherwise required by the authority having jurisdiction. Maintain consistent color coding throughout project.
  2. Color Coding Method: Integrally colored insulation.
    - a. Conductors size 4 AWG and larger may have black insulation color coded using vinyl color coding electrical tape.
  3. Color Code:
    - a. 480Y/277 V, 3 Phase, 4 Wire System:
      - 1) Phase A: Brown.
      - 2) Phase B: Orange.



- 3) Phase C: Yellow.
- 4) Neutral/Grounded: Gray.
- b. 208Y/120 V, 3 Phase, 4 Wire System:
  - 1) Phase A: Black.
  - 2) Phase B: Red.
  - 3) Phase C: Blue.
  - 4) Neutral/Grounded: White.
- c. Equipment Ground, All Systems: Green.

**2.03 SINGLE CONDUCTOR BUILDING WIRE**

- A. Description: Single conductor insulated wire.
- B. Conductor Stranding:
  - 1. Feeders and Branch Circuits:
    - a. Size 10 AWG and Smaller: Solid.
    - b. Size 8 AWG and Larger: Stranded.
- C. Insulation Voltage Rating: 600 V.
- D. Insulation:
  - 1. Copper Building Wire: Type THHN/THWN or THHN/THWN-2, except as indicated below.
    - a. Size 4 AWG and Larger: Type XHHW-2.
  - 2. Aluminum Building Wire (only where specifically indicated or permitted for substitution): Type XHHW-2.

**2.04 SERVICE ENTRANCE CABLE**

- A. Conductor Stranding: Stranded.
- B. Insulation Voltage Rating: 600 V.

**2.05 METAL-CLAD CABLE**

- A. Description: NFPA 70, Type MC cable listed and labeled as complying with UL 1569, and listed for use in classified firestop systems to be used.
- B. Conductor Stranding:
  - 1. Size 10 AWG and Smaller: Solid.
  - 2. Size 8 AWG and Larger: Stranded.
- C. Insulation Voltage Rating: 600 V.
- D. Insulation: Type THHN, THHN/THWN, or THHN/THWN-2.
- E. Grounding: Full-size integral equipment grounding conductor.
- F. Armor: Steel, interlocked tape.

**2.06 MANUFACTURED WIRING SYSTEMS**

- A. Description: Manufactured wiring assemblies complying with NFPA 70 Article 604, and listed and labeled as complying with UL 183.
- B. Provide components necessary to transition between manufactured wiring system and other wiring methods.
- C. Branch Circuit Cables:
  - 1. Conductor Stranding (Size 10 AWG and Smaller): Solid.
  - 2. Insulation Voltage Rating: 600 V.
  - 3. Insulation: Type THHN.
  - 4. Provide dedicated neutral conductor for each phase conductor where indicated or required.
  - 5. Grounding: Full-size integral equipment grounding conductor.
  - 6. Armor: Steel, interlocked tape.
- D. Connectors: Keyed and color-coded to prevent interconnection of different voltages.

- E. Fixture Leads: Type TFN insulation.

## **2.07 WIRING CONNECTORS**

- A. Description: Wiring connectors appropriate for the application, suitable for use with the conductors to be connected, and listed as complying with UL 486A-486B or UL 486C as applicable.
- B. Wiring Connectors for Splices and Taps:
  - 1. Copper Conductors Size 6 AWG and Larger: Use mechanical connectors or compression connectors.
  - 2. Connectors for Aluminum Conductors: Use compression connectors.
- C. Wiring Connectors for Terminations:
  - 1. Provide terminal lugs for connecting conductors to equipment furnished with terminations designed for terminal lugs.
  - 2. Provide compression adapters for connecting conductors to equipment furnished with mechanical lugs when only compression connectors are specified.
  - 3. Where over-sized conductors are larger than the equipment terminations can accommodate, provide connectors suitable for reducing to appropriate size, but not less than required for the rating of the overcurrent protective device.
  - 4. Provide motor pigtail connectors for connecting motor leads in order to facilitate disconnection.
  - 5. Copper Conductors Size 8 AWG and Larger: Use mechanical connectors or compression connectors where connectors are required.
  - 6. Aluminum Conductors: Use compression connectors for all connections.
- D. Mechanical Connectors: Provide bolted type or set-screw type.
- E. Compression Connectors: Provide circumferential type or hex type crimp configuration.

## **2.08 WIRING ACCESSORIES**

- A. Electrical Tape:
  - 1. Vinyl Color Coding Electrical Tape: Integrally colored to match color code indicated; listed as complying with UL 510; minimum thickness of 7 mil; resistant to abrasion, corrosion, and sunlight; suitable for continuous temperature environment up to 221 degrees F.
  - 2. Vinyl Insulating Electrical Tape: Complying with ASTM D3005 and listed as complying with UL 510; minimum thickness of 7 mil; resistant to abrasion, corrosion, and sunlight; conformable for application down to 0 degrees F and suitable for continuous temperature environment up to 221 degrees F.
- B. Oxide Inhibiting Compound: Listed; suitable for use with the conductors or cables to be installed.
- C. Wire Pulling Lubricant: Listed; suitable for use with the conductors or cables to be installed and suitable for use at the installation temperature.
- D. Cable Ties: Material and tensile strength rating suitable for application.

## **PART 3 EXECUTION**

### **3.01 EXAMINATION**

- A. Verify that interior of building has been protected from weather.
- B. Verify that work likely to damage wire and cable has been completed.
- C. Verify that raceways, boxes, and equipment enclosures are installed and are properly sized to accommodate conductors and cables in accordance with NFPA 70.
- D. Verify that field measurements are as indicated.
- E. Verify that conditions are satisfactory for installation prior to starting work.

### 3.02 PREPARATION

- A. Clean raceways thoroughly to remove foreign materials before installing conductors and cables.

### 3.03 INSTALLATION

- A. Circuiting Requirements:
  - 1. Unless dimensioned, circuit routing indicated is diagrammatic.
  - 2. When circuit destination is indicated without specific routing, determine exact routing required.
  - 3. Arrange circuiting to minimize splices.
  - 4. Include circuit lengths required to install connected devices within 10 ft of location indicated.
  - 5. Maintain separation of Class 1, Class 2, and Class 3 remote-control, signaling, and power-limited circuits in accordance with NFPA 70.
  - 6. Maintain separation of wiring for emergency systems in accordance with NFPA 70.
  - 7. Circuiting Adjustments: Unless otherwise indicated, when branch circuits are indicated as separate, combining them together in a single raceway is not permitted.
    - a. Provide no more than six current-carrying conductors in a single raceway. Dedicated neutral conductors are considered current-carrying conductors.
    - b. Increase size of conductors as required to account for ampacity derating.
    - c. Size raceways, boxes, etc. to accommodate conductors.
  - 8. Common Neutrals: Unless otherwise indicated, sharing of neutral/grounded conductors among up to three single phase branch circuits of different phases installed in the same raceway is not permitted. Provide dedicated neutral/grounded conductor for each individual branch circuit.
    - a. Branch circuits fed from ground fault circuit interrupter (GFCI) circuit breakers.
    - b. Branch circuits fed from feed-through protection of GFI receptacles.
    - c. Branch circuits with dimming controls.
    - d. Branch circuits with isolated grounding conductor.
- B. Install products in accordance with manufacturer's instructions.
- C. Perform work in accordance with NECA 1 (general workmanship).
- D. Install aluminum conductors in accordance with NECA 104.
- E. Install metal-clad cable (Type MC) in accordance with NECA 120.
- F. Installation in Raceway:
  - 1. Tape ends of conductors and cables to prevent infiltration of moisture and other contaminants.
  - 2. Pull all conductors and cables together into raceway at same time.
  - 3. Do not damage conductors and cables or exceed manufacturer's recommended maximum pulling tension and sidewall pressure.
  - 4. Use suitable wire pulling lubricant where necessary, except when lubricant is not recommended by the manufacturer.
- G. Paralleled Conductors: Install conductors of the same length and terminate in the same manner.
- H. Secure and support conductors and cables in accordance with NFPA 70 using suitable supports and methods approved by the authority having jurisdiction. Provide independent support from building structure. Do not provide support from raceways, piping, ductwork, or other systems.
- I. Terminate cables using suitable fittings.
  - 1. Metal-Clad Cable (Type MC):
    - a. Use listed fittings.

- b. Cut cable armor only using specialized tools to prevent damaging conductors or insulation. Do not use hacksaw or wire cutters to cut armor.
  - c. Do not use direct-bearing set-screw type fittings for cables with aluminum armor.
- J. Install conductors with a minimum of 12 inches of slack at each outlet.
- K. Neatly train and bundle conductors inside boxes, wireways, panelboards and other equipment enclosures.
- L. Group or otherwise identify neutral/grounded conductors with associated ungrounded conductors inside enclosures in accordance with NFPA 70.
- M. Make wiring connections using specified wiring connectors.
  - 1. Make splices and taps only in accessible boxes. Do not pull splices into raceways or make splices in conduit bodies or wiring gutters.
  - 2. Remove appropriate amount of conductor insulation for making connections without cutting, nicking or damaging conductors.
  - 3. Do not remove conductor strands to facilitate insertion into connector.
  - 4. Clean contact surfaces on conductors and connectors to suitable remove corrosion, oxides, and other contaminates. Do not use wire brush on plated connector surfaces.
  - 5. Connections for Aluminum Conductors: Fill connectors with oxide inhibiting compound where not pre-filled by manufacturer.
  - 6. Mechanical Connectors: Secure connections according to manufacturer's recommended torque settings.
  - 7. Compression Connectors: Secure connections using manufacturer's recommended tools and dies.
- N. Insulate splices and taps that are made with uninsulated connectors using methods suitable for the application, with insulation and mechanical strength at least equivalent to unspliced conductors.
- O. Insulate ends of spare conductors using vinyl insulating electrical tape.
- P. Field-Applied Color Coding: Where vinyl color coding electrical tape is used in lieu of integrally colored insulation as permitted in Part 2 under "Color Coding", apply half overlapping turns of tape at each termination and at each location conductors are accessible.
- Q. Install firestopping to preserve fire resistance rating of partitions and other elements, using materials and methods specified in Section 07 8400.
- R. Unless specifically indicated to be excluded, provide final connections to all equipment and devices, including those furnished by others, as required for a complete operating system.

**END OF SECTION**

**SECTION 26 0526**  
**GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS**

**PART 1 GENERAL**

**1.01 SECTION INCLUDES**

- A. Grounding and bonding requirements.
- B. Conductors for grounding and bonding.
- C. Connectors for grounding and bonding.
- D. Ground bars.
- E. Ground rod electrodes.

**1.02 ADMINISTRATIVE REQUIREMENTS**

- A. Coordination:
  - 1. Verify exact locations of underground metal water service pipe entrances to building.
  - 2. Coordinate the work with other trades to provide steel reinforcement complying with specified requirements for concrete-encased electrode.
  - 3. Notify Architect of any conflicts with or deviations from the contract documents. Obtain direction before proceeding with work.
- B. Sequencing:
  - 1. Do not install ground rod electrodes until final backfill and compaction is complete.

**1.03 QUALITY ASSURANCE**

- A. Conform to requirements of NFPA 70.

**1.04 DELIVERY, STORAGE, AND HANDLING**

- A. Receive, inspect, handle, and store products in accordance with manufacturer's instructions.

**PART 2 PRODUCTS**

**2.01 GROUNDING AND BONDING REQUIREMENTS**

- A. Do not use products for applications other than as permitted by NFPA 70 and product listing.
- B. Unless specifically indicated to be excluded, provide all required components, conductors, connectors, conduit, boxes, fittings, supports, accessories, etc. as necessary for a complete grounding and bonding system.
- C. Where conductor size is not indicated, size to comply with NFPA 70 but not less than applicable minimum size requirements specified.
- D. Grounding System Resistance:
  - 1. Achieve specified grounding system resistance under normally dry conditions unless otherwise approved by Architect. Precipitation within the previous 48 hours does not constitute normally dry conditions.
  - 2. Grounding Electrode System: Not greater than 5 ohms to ground, when tested according to IEEE 81 using "fall-of-potential" method.
  - 3. Between Grounding Electrode System and Major Electrical Equipment Frames, System Neutral, and Derived Neutral Points: Not greater than 0.5 ohms, when tested using "point-to-point" methods.
- E. Grounding Electrode System:
  - 1. Provide connection to required and supplemental grounding electrodes indicated to form grounding electrode system.
    - a. Provide continuous grounding electrode conductors without splice or joint.
    - b. Install grounding electrode conductors in raceway where exposed to physical damage. Bond grounding electrode conductor to metallic raceways at each end with bonding jumper.
  - 2. Metal Underground Water Pipe(s):

- a. Provide connection to underground metal domestic and fire protection (where present) water service pipe(s) that are in direct contact with earth for at least 10 feet at an accessible location not more than 5 feet from the point of entrance to the building.
  - b. Provide bonding jumper(s) around insulating joints/pipes as required to make pipe electrically continuous.
  - c. Provide bonding jumper around water meter of sufficient length to permit removal of meter without disconnecting jumper.
3. Metal In-Ground Support Structure:
    - a. Provide connection to metal in-ground support structure that is in direct contact with earth in accordance with NFPA 70.
  4. Concrete-Encased Electrode:
    - a. Provide connection to concrete-encased electrode consisting of not less than 20 feet of either steel reinforcing bars or bare copper conductor not smaller than 4 AWG embedded within concrete foundation or footing that is in direct contact with earth in accordance with NFPA 70.
  5. Ground Rod Electrode(s):
    - a. Provide three electrodes in an equilateral triangle configuration unless otherwise indicated or required.
    - b. Space electrodes not less than 10 feet from each other and any other ground electrode.
  6. Provide additional ground electrode(s) as required to achieve specified grounding electrode system resistance.
  7. Ground Bar: Provide ground bar, separate from service equipment enclosure, for common connection point of grounding electrode system bonding jumpers as permitted in NFPA 70. Connect grounding electrode conductor provided for service-supplied system grounding to this ground bar.
    - a. Ground Bar Size: 1/4 by 2 by 12 inches unless otherwise indicated or required.
    - b. Where ground bar location is not indicated, locate in accessible location as near as possible to service disconnect enclosure.
    - c. Ground Bar Mounting Height: 18 inches above finished floor unless otherwise indicated.
- F. Bonding and Equipment Grounding:
1. Provide bonding for equipment grounding conductors, equipment ground busses, metallic equipment enclosures, metallic raceways and boxes, device grounding terminals, and other normally non-current-carrying conductive materials enclosing electrical conductors/equipment or likely to become energized as indicated and in accordance with NFPA 70.
  2. Provide insulated equipment grounding conductor in each feeder and branch circuit raceway. Do not use raceways as sole equipment grounding conductor.
  3. Where circuit conductor sizes are increased for voltage drop, increase size of equipment grounding conductor proportionally in accordance with NFPA 70.
  4. Unless otherwise indicated, connect wiring device grounding terminal to branch circuit equipment grounding conductor and to outlet box with bonding jumper.
  5. Terminate branch circuit equipment grounding conductors on solidly bonded equipment ground bus only. Do not terminate on neutral (grounded) or isolated/insulated ground bus.
  6. Provide bonding jumper across expansion or expansion/deflection fittings provided to accommodate conduit movement.
  7. Provide bonding for interior metal piping systems in accordance with NFPA 70. This includes, but is not limited to:
    - a. Metal water piping where not already effectively bonded to metal underground water pipe used as grounding electrode.

## 2.02 GROUNDING AND BONDING COMPONENTS

### A. General Requirements:

1. Provide products listed, classified, and labeled as suitable for the purpose intended.
  2. Provide products listed and labeled as complying with UL 467 where applicable.
- B. Conductors for Grounding and Bonding, in Addition to Requirements of Section 26 0526:
1. Use insulated copper conductors unless otherwise indicated.
    - a. Exceptions:
      - 1) Use bare copper conductors where installed underground in direct contact with earth.
      - 2) Use bare copper conductors where directly encased in concrete (not in raceway).
- C. Connectors for Grounding and Bonding:
1. Description: Connectors appropriate for the application and suitable for the conductors and items to be connected; listed and labeled as complying with UL 467.
  2. Unless otherwise indicated, use exothermic welded connections for underground, concealed and other inaccessible connections.
  3. Unless otherwise indicated, use mechanical connectors, compression connectors, or exothermic welded connections for accessible connections.
- D. Ground Bars:
1. Description: Copper rectangular ground bars with mounting brackets and insulators.
  2. Holes for Connections: As indicated or as required for connections to be made.
- E. Ground Rod Electrodes:
1. Comply with NEMA GR 1.
  2. Material: Copper-bonded (copper-clad) steel.
  3. Size: 3/4 inch diameter by 10 feet length, unless otherwise indicated.

## **PART 3 EXECUTION**

### **3.01 EXAMINATION**

- A. Verify that work likely to damage grounding and bonding system components has been completed.
- B. Verify that field measurements are as indicated.
- C. Verify that conditions are satisfactory for installation prior to starting work.

### **3.02 INSTALLATION**

- A. Install products in accordance with manufacturer's instructions.
- B. Perform work in accordance with NECA 1 (general workmanship).
- C. Ground Rod Electrodes: Unless otherwise indicated, install ground rod electrodes vertically. Where encountered rock prohibits vertical installation, install at 45 degree angle or bury horizontally in trench at least 30 inches (750 mm) deep in accordance with NFPA 70 or provide ground plates.
  1. Outdoor Installations: Unless otherwise indicated, install with top of rod 6 inches below finished grade.
  2. Indoor Installations: Unless otherwise indicated, install with 4 inches of top of rod exposed.
- D. Make grounding and bonding connections using specified connectors.
  1. Remove appropriate amount of conductor insulation for making connections without cutting, nicking or damaging conductors. Do not remove conductor strands to facilitate insertion into connector.
  2. Remove nonconductive paint, enamel, or similar coating at threads, contact points, and contact surfaces.
  3. Exothermic Welds: Make connections using molds and weld material suitable for the items to be connected in accordance with manufacturer's recommendations.
  4. Mechanical Connectors: Secure connections according to manufacturer's recommended torque settings.

5. Compression Connectors: Secure connections using manufacturer's recommended tools and dies.
- E. Identify grounding and bonding system components in accordance with Section 26 0553.

**END OF SECTION**



**SECTION 26 0529**  
**HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS**

**PART 1 GENERAL**

**1.01 SECTION INCLUDES**

- A. Support and attachment components for equipment, conduit, cable, boxes, and other electrical work.

**1.02 ADMINISTRATIVE REQUIREMENTS**

- A. Coordination:
  - 1. Coordinate sizes and arrangement of supports and bases with the actual equipment and components to be installed.
  - 2. Coordinate the work with other trades to provide additional framing and materials required for installation.
  - 3. Coordinate compatibility of support and attachment components with mounting surfaces at the installed locations.
  - 4. Coordinate the arrangement of supports with ductwork, piping, equipment and other potential conflicts installed under other sections or by others.
  - 5. Notify Architect of any conflicts with or deviations from the contract documents. Obtain direction before proceeding with work.

**1.03 QUALITY ASSURANCE**

- A. Comply with NFPA 70.
- B. Comply with applicable building code.

**1.04 DELIVERY, STORAGE, AND HANDLING**

- A. Receive, inspect, handle, and store products in accordance with manufacturer's instructions.

**PART 2 PRODUCTS**

**2.01 SUPPORT AND ATTACHMENT COMPONENTS**

- A. General Requirements:
  - 1. Provide all required hangers, supports, anchors, fasteners, fittings, accessories, and hardware as necessary for the complete installation of electrical work.
  - 2. Provide products listed, classified, and labeled as suitable for the purpose intended, where applicable.
  - 3. Do not use products for applications other than as permitted by NFPA 70 and product listing.
  - 4. Do not use wire, chain, perforated pipe strap, or wood for permanent supports unless specifically indicated or permitted.
  - 5. Steel Components: Use corrosion resistant materials suitable for the environment where installed.
    - a. Indoor Dry Locations: Use zinc-plated steel or approved equivalent unless otherwise indicated.
    - b. Outdoor and Damp or Wet Indoor Locations: Use galvanized steel, stainless steel, or approved equivalent unless otherwise indicated.
    - c. Zinc-Plated Steel: Electroplated in accordance with ASTM B633.
    - d. Galvanized Steel: Hot-dip galvanized after fabrication in accordance with ASTM A123/A123M or ASTM A153/A153M.
- B. Conduit and Cable Supports: Straps, clamps, etc. suitable for the conduit or cable to be supported.
  - 1. Conduit Straps: One-hole or two-hole type; steel or malleable iron.
  - 2. Conduit Clamps: Bolted type unless otherwise indicated.
- C. Outlet Box Supports: Hangers, brackets, etc. suitable for the boxes to be supported.

- D. Metal Channel (Strut) Framing Systems: Factory-fabricated continuous-slot metal channel (strut) and associated fittings, accessories, and hardware required for field-assembly of supports.
  - 1. Comply with MFMA-4.
- E. Hanger Rods: Threaded zinc-plated steel unless otherwise indicated.
- F. Anchors and Fasteners:
  - 1. Unless otherwise indicated and where not otherwise restricted, use the anchor and fastener types indicated for the specified applications.

## **PART 3 EXECUTION**

### **3.01 INSTALLATION**

- A. Install products in accordance with manufacturer's instructions.
- B. Perform work in accordance with NECA 1 (general workmanship).
- C. Provide independent support from building structure. Do not provide support from piping, ductwork, or other systems.
- D. Unless specifically indicated or approved by Architect, do not provide support from suspended ceiling support system or ceiling grid.
- E. Unless specifically indicated or approved by Architect, do not provide support from roof deck.
- F. Do not penetrate or otherwise notch or cut structural members without approval of Structural Engineer.
- G. Equipment Support and Attachment:
  - 1. Use metal fabricated supports or supports assembled from metal channel (strut) to support equipment as required.
  - 2. Use metal channel (strut) secured to studs to support equipment surface-mounted on hollow stud walls when wall strength is not sufficient to resist pull-out.
  - 3. Use metal channel (strut) to support surface-mounted equipment in wet or damp locations to provide space between equipment and mounting surface.
  - 4. Securely fasten floor-mounted equipment. Do not install equipment such that it relies on its own weight for support.
- H. Secure fasteners according to manufacturer's recommended torque settings.
- I. Remove temporary supports.

**END OF SECTION**

**SECTION 26 0533.13**  
**CONDUIT FOR ELECTRICAL SYSTEMS**

**PART 1 GENERAL**

**1.01 SECTION INCLUDES**

- A. Galvanized steel rigid metal conduit (RMC).
- B. Aluminum rigid metal conduit (RMC).
- C. Intermediate metal conduit (IMC).
- D. PVC-coated galvanized steel rigid metal conduit (RMC).
- E. Flexible metal conduit (FMC).
- F. Liquidtight flexible metal conduit (LFMC).
- G. Electrical metallic tubing (EMT).
- H. Rigid polyvinyl chloride (PVC) conduit.
- I. Electrical nonmetallic tubing (ENT).
- J. Liquidtight flexible nonmetallic conduit (LFNC).
- K. Reinforced thermosetting resin conduit (RTRC).
- L. Conduit fittings.
- M. Accessories.

**1.02 ADMINISTRATIVE REQUIREMENTS**

- A. Coordination:
  - 1. Coordinate minimum sizes of conduits with the actual conductors to be installed, including adjustments for conductor sizes increased for voltage drop.
  - 2. Coordinate the arrangement of conduits with structural members, ductwork, piping, equipment and other potential conflicts installed under other sections or by others.
  - 3. Verify exact conduit termination locations required for boxes, enclosures, and equipment installed under other sections or by others.
  - 4. Coordinate the work with other trades to provide roof penetrations that preserve the integrity of the roofing system and do not void the roof warranty.
  - 5. Notify Architect of any conflicts with or deviations from the contract documents. Obtain direction before proceeding with work.
- B. Sequencing:
  - 1. Do not begin installation of conductors and cables until installation of conduit is complete between outlet, junction and splicing points.

**1.03 QUALITY ASSURANCE**

- A. Conform to requirements of NFPA 70.

**PART 2 PRODUCTS**

**2.01 CONDUIT APPLICATIONS**

- A. Do not use conduit and associated fittings for applications other than as permitted by NFPA 70 and product listing.
- B. Unless otherwise indicated and where not otherwise restricted, use the conduit types indicated for the specified applications. Where more than one listed application applies, comply with the most restrictive requirements. Where conduit type for a particular application is not specified, use galvanized steel rigid metal conduit.
- C. Underground:
  - 1. Under Slab on Grade: Use galvanized steel rigid metal conduit, intermediate metal conduit (IMC), PVC-coated galvanized steel rigid metal conduit, rigid PVC conduit, or reinforced thermosetting resin conduit (RTRC).

2. Exterior, Direct-Buried: Use galvanized steel rigid metal conduit, intermediate metallic conduit (IMC), PVC-coated galvanized steel rigid metal conduit, rigid PVC conduit, or reinforced thermosetting resin conduit (RTRC).
  3. Exterior, Embedded Within Concrete: Use galvanized steel rigid metal conduit, intermediate metallic conduit (IMC), PVC-coated galvanized steel rigid metal conduit, rigid PVC conduit, or reinforced thermosetting resin conduit (RTRC).
  4. Where rigid polyvinyl (PVC) conduit is provided, transition to galvanized steel rigid metal conduit where emerging from underground.
  5. Where rigid polyvinyl (PVC) conduit larger than 2 inch (53 mm) trade size is provided, use galvanized steel rigid metal conduit elbows for bends.
  6. Where steel conduit is installed in direct contact with earth where soil has a resistivity of less than 2000 ohm-centimeters or is characterized as severely corrosive based on soils report or local experience, use corrosion protection tape to provide supplementary corrosion protection or use PVC-coated galvanized steel rigid metal conduit.
  7. Where steel conduit emerges from concrete into soil, use corrosion protection tape to provide supplementary corrosion protection for a minimum of 4 inches on either side of where conduit emerges or use PVC-coated galvanized steel rigid metal conduit.
- D. Concealed Above Accessible Ceilings: Use galvanized steel rigid metal conduit, intermediate metal conduit (IMC), or electrical metallic tubing (EMT).
  - E. Interior, Damp or Wet Locations: Use galvanized steel rigid metal conduit.
  - F. Exposed, Interior, Not Subject to Physical Damage: Use galvanized steel rigid metal conduit, intermediate metal conduit (IMC), or electrical metallic tubing (EMT).
  - G. Exposed, Interior, Subject to Physical Damage: Use galvanized steel rigid metal conduit or intermediate metal conduit (IMC).
  - H. Exposed, Exterior: Use galvanized steel rigid metal conduit, intermediate metal conduit (IMC), or PVC-coated galvanized steel rigid metal conduit.
  - I. Concealed, Exterior, Not Embedded in Concrete or in Contact With Earth: Use galvanized steel rigid metal conduit or intermediate metal conduit (IMC).
  - J. Corrosive Locations Above Ground: Use PVC-coated galvanized steel rigid metal conduit, aluminum rigid metal conduit, or reinforced thermosetting resin conduit (RTRC).
  - K. Connections to Luminaires Above Accessible Ceilings: Use flexible metal conduit.
    1. Maximum Length: 6 feet.
  - L. Connections to Vibrating Equipment:
    1. Dry Locations: Use flexible metal conduit.
    2. Damp, Wet, or Corrosive Locations: Use liquidtight flexible metal conduit.
    3. Maximum Length: 6 feet unless otherwise indicated.
    4. Vibrating equipment includes, but is not limited to:
      - a. Transformers.
      - b. Motors.

## 2.02 CONDUIT REQUIREMENTS

- A. Existing Work: Where existing conduits are indicated to be reused, they may be reused only where they comply with specified requirements, are free from corrosion, and integrity is verified by pulling a mandrel through them.
- B. Electrical Service Conduits: Also comply with Section 26 2100.
- C. Fittings for Grounding and Bonding: Also comply with Section 26 0526.
- D. Provide all conduit, fittings, supports, and accessories required for a complete raceway system.
- E. Provide products listed, classified, and labeled as suitable for the purpose intended.
- F. Minimum Conduit Size, Unless Otherwise Indicated:
  1. Branch Circuits: 1/2 inch (16 mm) trade size.
  2. Branch Circuit Homeruns: 3/4 inch (21 mm) trade size.

- G. Where conduit size is not indicated, size to comply with NFPA 70 but not less than applicable minimum size requirements specified.

### **2.03 GALVANIZED STEEL RIGID METAL CONDUIT (RMC)**

- A. Description: NFPA 70, Type RMC galvanized steel rigid metal conduit complying with ANSI C80.1 and listed and labeled as complying with UL 6.
- B. Fittings:
  - 1. Non-Hazardous Locations: Use fittings complying with NEMA FB 1 and listed and labeled as complying with UL 514B.
  - 2. Material: Use steel or malleable iron.
  - 3. Connectors and Couplings: Use threaded type fittings only. Threadless set screw and compression (gland) type fittings are not permitted.

### **2.04 ALUMINUM RIGID METAL CONDUIT (RMC)**

- A. Description: NFPA 70, Type RMC aluminum rigid metal conduit complying with ANSI C80.5 and listed and labeled as complying with UL 6A.
- B. Fittings:
  - 1. Non-Hazardous Locations: Use fittings complying with NEMA FB 1 and listed and labeled as complying with UL 514B.
  - 2. Material: Use aluminum.
  - 3. Connectors and Couplings: Use threaded type fittings only. Threadless set screw and compression (gland) type fittings are not permitted.

### **2.05 INTERMEDIATE METAL CONDUIT (IMC)**

- A. Description: NFPA 70, Type IMC galvanized steel intermediate metal conduit complying with ANSI C80.6 and listed and labeled as complying with UL 1242.
- B. Fittings:
  - 1. Non-Hazardous Locations: Use fittings complying with NEMA FB 1 and listed and labeled as complying with UL 514B.
  - 2. Material: Use steel or malleable iron.
  - 3. Connectors and Couplings: Use threaded type fittings only. Threadless set screw and compression (gland) type fittings are not permitted.

### **2.06 PVC-COATED GALVANIZED STEEL RIGID METAL CONDUIT (RMC)**

- A. Description: NFPA 70, Type RMC galvanized steel rigid metal conduit with external polyvinyl chloride (PVC) coating complying with NEMA RN 1 and listed and labeled as complying with UL 6.
- B. Exterior Coating: Polyvinyl chloride (PVC), nominal thickness of 40 mil.
- C. PVC-Coated Fittings:
  - 1. Manufacturer: Same as manufacturer of PVC-coated conduit to be installed.
  - 2. Non-Hazardous Locations: Use fittings listed and labeled as complying with UL 514B.
  - 3. Material: Use steel or malleable iron.
  - 4. Exterior Coating: Polyvinyl chloride (PVC), minimum thickness of 40 mil.
- D. PVC-Coated Supports: Furnish with exterior coating of polyvinyl chloride (PVC), minimum thickness of 15 mil.

### **2.07 FLEXIBLE METAL CONDUIT (FMC)**

- A. Description: NFPA 70, Type FMC standard wall steel flexible metal conduit listed and labeled as complying with UL 1, and listed for use in classified firestop systems to be used.
- B. Fittings:
  - 1. Description: Fittings complying with NEMA FB 1 and listed and labeled as complying with UL 514B.
  - 2. Material: Use steel or malleable iron.

## **2.08 LIQUIDTIGHT FLEXIBLE METAL CONDUIT (LFMC)**

- A. Description: NFPA 70, Type LFMC polyvinyl chloride (PVC) jacketed steel flexible metal conduit listed and labeled as complying with UL 360.
- B. Fittings:
  - 1. Description: Fittings complying with NEMA FB 1 and listed and labeled as complying with UL 514B.
  - 2. Material: Use steel or malleable iron.

## **2.09 ELECTRICAL METALLIC TUBING (EMT)**

- A. Description: NFPA 70, Type EMT steel electrical metallic tubing complying with ANSI C80.3 and listed and labeled as complying with UL 797.
- B. Fittings:
  - 1. Description: Fittings complying with NEMA FB 1 and listed and labeled as complying with UL 514B.
  - 2. Material: Use steel or malleable iron.
  - 3. Connectors and Couplings: Use compression (gland) or set-screw type.
    - a. Do not use indenter type connectors and couplings.

## **2.10 RIGID POLYVINYL CHLORIDE (PVC) CONDUIT**

- A. Description: NFPA 70, Type PVC rigid polyvinyl chloride conduit complying with NEMA TC 2 and listed and labeled as complying with UL 651; Schedule 40 unless otherwise indicated, Schedule 80 where subject to physical damage; rated for use with conductors rated 90 degrees C.
- B. Fittings:
  - 1. Manufacturer: Same as manufacturer of conduit to be connected.
  - 2. Description: Fittings complying with NEMA TC 3 and listed and labeled as complying with UL 651; material to match conduit.

## **2.11 ELECTRICAL NONMETALLIC TUBING (ENT)**

- A. Description: NFPA 70, Type ENT electrical nonmetallic tubing complying with NEMA TC 13 and listed and labeled as complying with UL 1653.
- B. Fittings:
  - 1. Manufacturer: Same as manufacturer of ENT to be connected.
  - 2. Use solvent-welded type fittings.
  - 3. Solvent-Welded Fittings: Rigid PVC fittings complying with NEMA TC 3 and listed and labeled as complying with UL 651; suitable for use with ENT.

## **2.12 LIQUIDTIGHT FLEXIBLE NONMETALLIC CONDUIT (LFNC)**

- A. Description: NFPA 70, Type LFNC liquidtight flexible nonmetallic conduit listed and labeled as complying with UL 1660.
- B. Fittings:
  - 1. Manufacturer: Same as manufacturer of conduit to be connected.
  - 2. Description: Fittings complying with NEMA FB 1 and listed and labeled as complying with UL 514B; suitable for the type of conduit to be connected.

## **2.13 REINFORCED THERMOSETTING RESIN CONDUIT (RTRC)**

- A. Description: NFPA 70, Type RTRC reinforced thermosetting resin conduit complying with NEMA TC 14 (SERIES).
- B. Supports: Per manufacturer's recommendations.
- C. Fittings: Same type and manufacturer as conduit to be connected.

## **2.14 ACCESSORIES**

- A. Corrosion Protection Tape: PVC-based, minimum thickness of 20 mil.

- B. Conduit Joint Compound: Corrosion-resistant, electrically conductive; suitable for use with the conduit to be installed.
- C. Solvent Cement for PVC Conduit and Fittings: As recommended by manufacturer of conduit and fittings to be installed.
- D. Epoxy Adhesive for RTRC Conduit and Fittings: As recommended by manufacturer of conduit and fittings to be installed.

## **PART 3 EXECUTION**

### **3.01 INSTALLATION**

- A. Install products in accordance with manufacturer's instructions.
- B. Perform work in accordance with NECA 1 (general workmanship).
- C. Install galvanized steel rigid metal conduit (RMC) in accordance with NECA 101.
- D. Install aluminum rigid metal conduit (RMC) in accordance with NECA 102.
- E. Install intermediate metal conduit (IMC) in accordance with NECA 101.
- F. Install PVC-coated galvanized steel rigid metal conduit (RMC) using only tools approved by the manufacturer.
- G. Install rigid polyvinyl chloride (PVC) conduit in accordance with NECA 111.
- H. Install electrical nonmetallic tubing (ENT) in accordance with NECA 111.
- I. Install liquidtight flexible nonmetallic conduit (LFNC) in accordance with NECA 111.
- J. Conduit Routing:
  - 1. Unless dimensioned, conduit routing indicated is diagrammatic.
  - 2. Conduits in the following areas may be exposed, unless otherwise indicated:
    - a. Electrical rooms.
    - b. Mechanical equipment rooms.
    - c. Within joists in areas with no ceiling.
  - 3. Unless otherwise approved, do not route conduits exposed:
    - a. Across floors.
    - b. Across building exterior surfaces.
- K. Conduit Support:
  - 1. Secure and support conduits in accordance with NFPA 70 and Section 26 0529 using suitable supports and methods approved by the authority having jurisdiction.
  - 2. Provide independent support from building structure. Do not provide support from piping, ductwork, or other systems.
  - 3. Installation Above Suspended Ceilings: Do not provide support from ceiling support system. Do not provide support from ceiling grid or allow conduits to lay on ceiling tiles.
- L. Connections and Terminations:
  - 1. Use approved zinc-rich paint or conduit joint compound on field-cut threads of galvanized steel conduits prior to making connections.
  - 2. Where two threaded conduits must be joined and neither can be rotated, use three-piece couplings or split couplings. Do not use running threads.
  - 3. Use suitable adapters where required to transition from one type of conduit to another.
  - 4. Provide drip loops for liquidtight flexible conduit connections to prevent drainage of liquid into connectors.
  - 5. Terminate threaded conduits in boxes and enclosures using threaded hubs or double lock nuts for dry locations and raintight hubs for wet locations.
  - 6. Provide insulating bushings or insulated throats at all conduit terminations to protect conductors.
  - 7. Secure joints and connections to provide maximum mechanical strength and electrical continuity.
- M. Penetrations:

1. Do not penetrate or otherwise notch or cut structural members, including footings and grade beams, without approval of Structural Engineer.
  2. Make penetrations perpendicular to surfaces unless otherwise indicated.
  3. Provide sleeves for penetrations as indicated or as required to facilitate installation. Set sleeves flush with exposed surfaces unless otherwise indicated or required.
  4. Conceal bends for conduit risers emerging above ground.
  5. Seal interior of conduits entering the building from underground at first accessible point to prevent entry of moisture and gases.
  6. Where conduits penetrate waterproof membrane, seal as required to maintain integrity of membrane.
  7. Make penetrations for roof-mounted equipment within associated equipment openings and curbs where possible to minimize roofing system penetrations. Where penetrations are necessary, seal as indicated or as required to preserve integrity of roofing system and maintain roof warranty. Include proposed locations of penetrations and methods for sealing with submittals.
  8. Install firestopping to preserve fire resistance rating of partitions and other elements, using materials and methods specified in Section 07 8400.
- N. Underground Installation:
1. Provide trenching and backfilling in accordance with Section 31 2316 and Section 31 2323.
  2. Minimum Cover, Unless Otherwise Indicated or Required:
    - a. Underground, Exterior: 24 inches.
    - b. Under Slab on Grade: 12 inches to bottom of slab.
  3. Provide underground warning tape in accordance with Section 26 0553 along entire conduit length for service entrance where not concrete-encased.
- O. Concrete Encasement: Where conduits not otherwise embedded within concrete are indicated to be concrete-encased, provide concrete in accordance with Section 03 3000 with minimum concrete cover of 3 inches on all sides unless otherwise indicated.
- P. Conduit Movement Provisions: Where conduits are subject to movement, provide expansion and expansion/deflection fittings to prevent damage to enclosed conductors or connected equipment. This includes, but is not limited to:
1. Where conduits cross structural joints intended for expansion, contraction, or deflection.
  2. Where calculated in accordance with NFPA 70 for rigid polyvinyl chloride (PVC) conduit installed above ground to compensate for thermal expansion and contraction.
  3. Where calculated in accordance with NFPA 70 for reinforced thermosetting resin conduit (RTRC) conduit installed above ground to compensate for thermal expansion and contraction.
  4. Where conduits are subject to earth movement by settlement or frost.
- Q. Condensation Prevention: Where conduits cross barriers between areas of potential substantial temperature differential, provide sealing fitting or approved sealing compound at an accessible point near the penetration to prevent condensation. This includes, but is not limited to:
1. Where conduits pass from outdoors into conditioned interior spaces.
  2. Where conduits pass from unconditioned interior spaces into conditioned interior spaces.
- R. Provide grounding and bonding in accordance with Section 26 0526.

### **3.02 CLEANING**

- A. Clean interior of conduits to remove moisture and foreign matter.

### **3.03 PROTECTION**

- A. Immediately after installation of conduit, use suitable manufactured plugs to provide protection from entry of moisture and foreign material and do not remove until ready for installation of conductors.

**END OF SECTION**



**SECTION 26 0534**  
**BOXES FOR ELECTRICAL SYSTEMS**

**PART 1 GENERAL**

**1.01 SECTION INCLUDES**

- A. Outlet and device boxes up to 100 cubic inches, including those used as junction and pull boxes.
- B. Cabinets and enclosures, including junction and pull boxes larger than 100 cubic inches.
- C. Boxes and enclosures for integrated power, data, and audio/video.
- D. Boxes for hazardous (classified) locations.
- E. Floor boxes.
- F. Underground boxes/enclosures.

**1.02 ADMINISTRATIVE REQUIREMENTS**

- A. Coordination:
  - 1. Coordinate the work with other trades to avoid placement of ductwork, piping, equipment, or other potential obstructions within the dedicated equipment spaces and working clearances for electrical equipment required by NFPA 70.
  - 2. Coordinate arrangement of electrical equipment with the dimensions and clearance requirements of the actual equipment to be installed.
  - 3. Coordinate minimum sizes of boxes with the actual installed arrangement of conductors, clamps, support fittings, and devices, calculated according to NFPA 70.
  - 4. Coordinate minimum sizes of pull boxes with the actual installed arrangement of connected conduits, calculated according to NFPA 70.
  - 5. Coordinate the placement of boxes with millwork, furniture, devices, equipment, etc. installed under other sections or by others.
  - 6. Coordinate the work with other trades to preserve insulation integrity.
  - 7. Coordinate the work with other trades to provide walls suitable for installation of flush-mounted boxes where indicated.
  - 8. Notify Architect of any conflicts with or deviations from the contract documents. Obtain direction before proceeding with work.

**PART 2 PRODUCTS**

**2.01 BOXES**

- A. General Requirements:
  - 1. Do not use boxes and associated accessories for applications other than as permitted by NFPA 70 and product listing.
  - 2. Provide all boxes, fittings, supports, and accessories required for a complete raceway system and to accommodate devices and equipment to be installed.
  - 3. Provide products listed, classified, and labeled as suitable for the purpose intended.
  - 4. Where box size is not indicated, size to comply with NFPA 70 but not less than applicable minimum size requirements specified.
  - 5. Provide grounding terminals within boxes where equipment grounding conductors terminate.
- B. Outlet and Device Boxes Up to 100 cubic inches, Including Those Used as Junction and Pull Boxes:
  - 1. Use sheet-steel boxes for dry locations unless otherwise indicated or required.
  - 2. Use cast iron boxes or cast aluminum boxes for damp or wet locations unless otherwise indicated or required; furnish with compatible weatherproof gasketed covers.
  - 3. Use suitable concrete type boxes where flush-mounted in concrete.
  - 4. Use suitable masonry type boxes where flush-mounted in masonry walls.
  - 5. Use raised covers suitable for the type of wall construction and device configuration where required.

6. Use shallow boxes where required by the type of wall construction.
  7. Do not use "through-wall" boxes designed for access from both sides of wall.
  8. Sheet-Steel Boxes: Comply with NEMA OS 1, and list and label as complying with UL 514A.
  9. Cast Metal Boxes: Comply with NEMA FB 1, and list and label as complying with UL 514A; furnish with threaded hubs.
  10. Boxes for Supporting Luminaires and Ceiling Fans: Listed as suitable for the type and weight of load to be supported; furnished with fixture stud to accommodate mounting of luminaire where required.
  11. Boxes for Ganged Devices: Use multigang boxes of single-piece construction. Do not use field-connected gangable boxes unless specifically indicated or permitted.
  12. Wall Plates: Comply with Section 26 2726.
- C. Cabinets and Enclosures, Including Junction and Pull Boxes Larger Than 100 cubic inches:
1. Comply with NEMA 250, and list and label as complying with UL 50 and UL 50E, or UL 508A.
  2. NEMA 250 Environment Type, Unless Otherwise Indicated:
  3. Junction and Pull Boxes Larger Than 100 cubic inches:
    - a. Provide screw-cover or hinged-cover enclosures unless otherwise indicated.
- D. Floor Boxes:
1. Description: Floor boxes compatible with floor box service fittings provided in accordance with Section 26 2726; with partitions to separate multiple services; furnished with all components, adapters, and trims required for complete installation.
  2. Manufacturer: Same as manufacturer of floor box service fittings.
- E. Underground Boxes/Enclosures:
1. Description: In-ground, open bottom boxes furnished with flush, non-skid covers with legend indicating type of service and stainless steel tamper resistant cover bolts.
  2. Size: As indicated on drawings.
  3. Depth: As required to extend below frost line to prevent frost upheaval, but not less than 12 inches.
  4. Applications:
    - a. Do not use polymer concrete enclosures in areas subject to deliberate vehicular traffic.

## **PART 3 EXECUTION**

### **3.01 INSTALLATION**

- A. Install products in accordance with manufacturer's instructions.
- B. Install boxes in accordance with NECA 1 (general workmanship) and, where applicable, NECA 130, including mounting heights specified in those standards where mounting heights are not indicated.
- C. Arrange equipment to provide minimum clearances in accordance with manufacturer's instructions and NFPA 70.
- D. Provide separate boxes for emergency power and normal power systems.
- E. Unless otherwise indicated, provide separate boxes for line voltage and low voltage systems.
- F. Flush-mount boxes in finished areas unless specifically indicated to be surface-mounted.
- G. Unless otherwise indicated, boxes may be surface-mounted where exposed conduits are indicated or permitted.
- H. Box Supports:
  1. Secure and support boxes in accordance with NFPA 70 and Section 26 0529 using suitable supports and methods approved by the authority having jurisdiction.
  2. Provide independent support from building structure except for cast metal boxes (other than boxes used for fixture support) supported by threaded conduit connections in

accordance with NFPA 70. Do not provide support from piping, ductwork, or other systems.

3. Installation Above Suspended Ceilings: Do not provide support from ceiling grid or ceiling support system.
- I. Install boxes plumb and level.
- J. Flush-Mounted Boxes:
  1. Install boxes in noncombustible materials such as concrete, tile, gypsum, plaster, etc. so that front edge of box or associated raised cover is not set back from finished surface more than 1/4 inch or does not project beyond finished surface.
  2. Install boxes in combustible materials such as wood so that front edge of box or associated raised cover is flush with finished surface.
  3. Repair rough openings around boxes in noncombustible materials such as concrete, tile, gypsum, plaster, etc. so that there are no gaps or open spaces greater than 1/8 inch at the edge of the box.
- K. Install boxes as required to preserve insulation integrity.
- L. Metallic Floor Boxes: Install box level at the proper elevation to be flush with finished floor.
- M. Nonmetallic Floor Boxes: Cut box flush with finished floor after concrete pour.
- N. Underground Boxes/Enclosures:
  1. Install enclosure on gravel base, minimum 6 inches deep.
  2. Install additional bracing inside enclosures in accordance with manufacturer's instructions to minimize box sidewall deflections during backfilling. Backfill with cover bolted in place.
- O. Install permanent barrier between ganged wiring devices when voltage between adjacent devices exceeds 300 V.
- P. Install firestopping to preserve fire resistance rating of partitions and other elements, using materials and methods specified in Section 07 8400.
- Q. Close unused box openings.
- R. Install blank wall plates on junction boxes and on outlet boxes with no devices or equipment installed or designated for future use.
- S. Provide grounding and bonding in accordance with Section 26 0526.

### **3.02 CLEANING**

- A. Clean interior of boxes to remove dirt, debris, plaster and other foreign material.

### **3.03 PROTECTION**

- A. Immediately after installation, protect boxes from entry of moisture and foreign material until ready for installation of conductors.

**END OF SECTION**



**SECTION 26 0535**  
**SURFACE RACEWAYS FOR ELECTRICAL SYSTEMS**

**PART 1 GENERAL**

**1.01 SECTION INCLUDES**

- A. Surface raceway systems.
- B. Wireways.

**1.02 ADMINISTRATIVE REQUIREMENTS**

- A. Coordination:
  - 1. Coordinate the placement of raceways with millwork, furniture, equipment, etc. installed under other sections or by others.
  - 2. Coordinate rough-in locations of outlet boxes provided under Section 26 0533.16 and conduit provided under Section 26 0533.13 as required for installation of raceways provided under this section.
  - 3. Verify minimum sizes of raceways with the actual conductors and components to be installed.
  - 4. Notify Architect of any conflicts with or deviations from the contract documents. Obtain direction before proceeding with work.
- B. Sequencing:
  - 1. Do not install raceways until final surface finishes and painting are complete.
  - 2. Do not begin installation of conductors and cables until installation of raceways is complete between outlet, junction and splicing points.

**PART 2 PRODUCTS**

**2.01 RACEWAY REQUIREMENTS**

- A. Provide all components, fittings, supports, and accessories required for a complete raceway system.
- B. Provide products listed, classified, and labeled as suitable for the purpose intended.
- C. Do not use raceways for applications other than as permitted by NFPA 70 and product listing.

**2.02 SURFACE RACEWAY SYSTEMS**

- A. Surface Metal Raceways: Listed and labeled as complying with UL 5.
- B. Surface Nonmetallic Raceways: Listed and labeled as complying with UL 5A.
- C. Multioutlet Assemblies: Listed and labeled as complying with UL 111.

**2.03 WIREWAYS**

- A. Description: Lay-in wireways and wiring troughs with removable covers; listed and labeled as complying with UL 870.
- B. Wireway Type, Unless Otherwise Indicated:
- C. Where wireway size is not indicated, size to comply with NFPA 70 but not less than applicable minimum size requirements specified.

**PART 3 EXECUTION**

**3.01 EXAMINATION**

- A. Verify that field measurements are as indicated.
- B. Verify that outlet boxes and conduit terminations are installed in proper locations and are properly sized in accordance with NFPA 70 to accommodate raceways.
- C. Verify that mounting surfaces are ready to receive raceways and that final surface finishes are complete, including painting.
- D. Verify that conditions are satisfactory for installation prior to starting work.

### **3.02 INSTALLATION**

- A. Install products in accordance with manufacturer's instructions.
- B. Perform work in accordance with NECA 1 (general workmanship).
- C. Install raceways plumb and level.
- D. Arrange wireways and associated raceway connections to comply with NFPA 70, including but not limited to requirements for deflected conductors and wireways used as pullboxes. Increase size of wireway where necessary.
- E. Secure and support raceways in accordance with Section 26 0529 at intervals complying with NFPA 70 and manufacturer's requirements.
- F. Close unused raceway openings.
- G. Provide grounding and bonding in accordance with Section 26 0526.

### **3.03 CLEANING**

- A. Clean exposed surfaces to remove dirt, paint, or other foreign material and restore to match original factory finish.

### **3.04 PROTECTION**

- A. Protect installed raceways from subsequent construction operations.

**END OF SECTION**

**SECTION 26 2100**  
**LOW-VOLTAGE ELECTRICAL SERVICE ENTRANCE**

**PART 1 GENERAL**

**1.01 SECTION INCLUDES**

- A. Electrical service requirements.

**1.02 DEFINITIONS**

- A. Service Point: The point of connection between the facilities of the serving utility and the premises wiring as defined in NFPA 70, and as designated by the Utility Company.

**1.03 ADMINISTRATIVE REQUIREMENTS**

- A. No later than two weeks following date of the Agreement, notify Utility Company of anticipated date of service.
- B. Coordination:
  - 1. Verify the following with Utility Company representative:
    - a. Utility Company requirements, including division of responsibility.
    - b. Exact location and details of utility point of connection.
    - c. Utility easement requirements.
    - d. Utility Company charges associated with providing service.
  - 2. Coordinate the work with other trades to avoid placement of other utilities or obstructions within the spaces dedicated for electrical service and associated equipment.
  - 3. Coordinate arrangement of service entrance equipment with the dimensions and clearance requirements of the actual equipment to be installed.
  - 4. Notify Architect of any conflicts with or deviations from the contract documents. Obtain direction before proceeding with work.
- C. Arrange for Utility Company to provide permanent electrical service. Prepare and submit documentation required by Utility Company.
- D. Utility Company charges associated with providing permanent service to be paid by Owner.
- E. Preinstallation Meeting: Convene one week prior to commencing work of this section to review service requirements and details with Utility Company representative.
- F. Scheduling:
  - 1. Where work of this section involves interruption of existing electrical service, arrange service interruption with Owner.
  - 2. Arrange for inspections necessary to obtain Utility Company approval of installation.

**1.04 QUALITY ASSURANCE**

- A. Comply with the following:
  - 1. IEEE C2 (National Electrical Safety Code).
  - 2. NFPA 70 (National Electrical Code).
  - 3. The requirements of the Utility Company.

**PART 2 PRODUCTS**

**2.01 ELECTRICAL SERVICE REQUIREMENTS**

- A. Provide new electrical service consisting of all required conduits, conductors, equipment, metering provisions, supports, accessories, etc. as necessary for connection between Utility Company point of supply and service entrance equipment.
- B. Electrical Service Characteristics: As indicated on drawings.
- C. Utility Company: As indicated on drawings.
- D. Division of Responsibility:
  - 1. Pad-Mounted Utility Transformers:
    - a. Transformer Vaults and Pads: Furnished and installed by Contractor per Utility Company requirements.

- b. Transformers: Furnished and installed by Utility Company.
  - c. Transformer Grounding Provisions: Furnished and installed by Contractor per Utility Company requirements.
  - d. Transformer Protective Bollards: Furnished and installed by Contractor per Utility Company requirements.
  - e. Primary:
    - 1) Trenching and Backfilling: Provided by Contractor.
    - 2) Conduits: Furnished and installed by Contractor.
    - 3) Conductors: Furnished and installed by Utility Company.
  - f. Secondary:
    - 1) Trenching and Backfilling: Provided by Contractor.
    - 2) Conduits: Furnished and installed by Contractor.
    - 3) Conductors: Furnished and installed by Contractor (Service Point at transformer).
  - 2. Terminations at Service Point: Provided by Utility Company.
  - 3. Metering Provisions:
    - a. Meter Bases: Furnished and installed by Contractor per Utility Company requirements.
    - b. Metering Transformer Cabinets: Furnished and installed by Contractor per Utility Company requirements.
    - c. Metering Compartments in Service Entrance Equipment: Furnished and installed by Contractor per Utility Company requirements.
    - d. Metering Transformers: Furnished and installed by Utility Company.
    - e. Conduits Between Metering Transformers and Meters: Furnished and installed by Contractor per Utility Company requirements.
    - f. Wiring Between Metering Transformers and Meters: Furnished and installed by Utility Company.
    - g. Communications Conduits for Meters: Furnished and installed by Contractor per Utility Company requirements.
- E. Products Furnished by Contractor: Comply with Utility Company requirements.

### **PART 3 EXECUTION**

#### **3.01 EXAMINATION**

- A. Verify that field measurements are as indicated.
- B. Verify that ratings and configurations of service entrance equipment are consistent with the indicated requirements.
- C. Verify that conditions are satisfactory for installation prior to starting work.

#### **3.02 PREPARATION**

- A. Verify and mark locations of existing underground utilities.

#### **3.03 INSTALLATION**

- A. Install products in accordance with manufacturer's instructions and Utility Company requirements.
- B. Perform work in accordance with NECA 1 (general workmanship).
- C. Arrange equipment to provide minimum clearances and required maintenance access.
- D. Provide required trenching and backfilling in accordance with Section 31 2316.13.
- E. Provide required support and attachment components in accordance with Section 26 0529.
- F. Provide grounding and bonding for service entrance equipment in accordance with Section 26 0526.
- G. Identify service entrance equipment, including main service disconnect(s) in accordance with Section 26 0553.



**3.04 PROTECTION**

- A. Protect installed equipment from subsequent construction operations.

**END OF SECTION**



**SECTION 26 2416  
PANELBOARDS**

**PART 1 GENERAL**

**1.01 SECTION INCLUDES**

- A. Power distribution panelboards.
- B. Lighting and appliance panelboards.
- C. Overcurrent protective devices for panelboards.

**1.02 ADMINISTRATIVE REQUIREMENTS**

- A. Coordination:
  - 1. Coordinate the work with other trades to avoid placement of ductwork, piping, equipment, or other potential obstructions within the dedicated equipment spaces and working clearances for electrical equipment required by NFPA 70.
  - 2. Coordinate arrangement of electrical equipment with the dimensions and clearance requirements of the actual equipment to be installed.
  - 3. Coordinate the work with other trades to provide walls suitable for installation of flush-mounted panelboards where indicated.
  - 4. Verify with manufacturer that conductor terminations are suitable for use with the conductors to be installed.
  - 5. Notify Architect of any conflicts with or deviations from the contract documents. Obtain direction before proceeding with work.

**1.03 SUBMITTALS**

- A. Product Data: Provide manufacturer's standard catalog pages and data sheets for panelboards, enclosures, overcurrent protective devices, and other installed components and accessories.
- B. Shop Drawings: Indicate outline and support point dimensions, voltage, main bus ampacity, overcurrent protective device arrangement and sizes, short circuit current ratings, conduit entry locations, conductor terminal information, and installed features and accessories.
  - 1. Include dimensioned plan and elevation views of panelboards and adjacent equipment with all required clearances indicated.
  - 2. Include wiring diagrams showing all factory and field connections.
  - 3. Clearly indicate whether proposed short circuit current ratings are fully rated or, where acceptable, series rated systems.
  - 4. Include documentation of listed series ratings upon request.

**1.04 QUALITY ASSURANCE**

- A. Conform to requirements of NFPA 70.

**1.05 DELIVERY, STORAGE, AND HANDLING**

- A. Receive, inspect, handle, and store panelboards in accordance with manufacturer's instructions and NECA 407.
- B. Store in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.
- C. Handle carefully in accordance with manufacturer's written instructions to avoid damage to panelboard internal components, enclosure, and finish.

**PART 2 PRODUCTS**

**2.01 MANUFACTURERS**

- A. Eaton Corporation; \_\_\_\_\_: [www.eaton.com/#sle](http://www.eaton.com/#sle).
- B. Schneider Electric; Square D Products; \_\_\_\_\_: [www.schneider-electric.us/#sle](http://www.schneider-electric.us/#sle).
- C. Siemens Industry, Inc; \_\_\_\_\_: [www.usa.siemens.com/#sle](http://www.usa.siemens.com/#sle).

- D. Source Limitations: Furnish panelboards and associated components produced by the same manufacturer as the other electrical distribution equipment used for this project and obtained from a single supplier.

## 2.02 PANELBOARDS - GENERAL REQUIREMENTS

- A. Provide products listed, classified, and labeled as suitable for the purpose intended.
- B. Short Circuit Current Rating:
  - 1. Provide panelboards with listed short circuit current rating not less than the available fault current at the installed location as indicated on the drawings.
  - 2. Label equipment utilizing series ratings as required by NFPA 70.
- C. Panelboards Used for Service Entrance: Listed and labeled as suitable for use as service equipment according to UL 869A.
- D. Mains: Configure for top or bottom incoming feed as indicated or as required for the installation.
- E. Branch Overcurrent Protective Devices: Replaceable without disturbing adjacent devices.
- F. Bussing: Sized in accordance with UL 67 temperature rise requirements.
  - 1. Provide fully rated neutral bus unless otherwise indicated, with a suitable lug for each feeder or branch circuit requiring a neutral connection.
  - 2. Provide solidly bonded equipment ground bus in each panelboard, with a suitable lug for each feeder and branch circuit equipment grounding conductor.
  - 3. Provide separate isolated/insulated ground bus where indicated or where isolated grounding conductors are provided.
- G. Conductor Terminations: Suitable for use with the conductors to be installed.
- H. Enclosures: Comply with NEMA 250, and list and label as complying with UL 50 and UL 50E.
  - 1. Environment Type per NEMA 250: Unless otherwise indicated, as specified for the following installation locations:
    - a. Indoor Clean, Dry Locations: Type 1.
    - b. Outdoor Locations: Type 3R.
  - 2. Boxes: Galvanized steel unless otherwise indicated.
    - a. Provide wiring gutters sized to accommodate the conductors to be installed.
    - b. Increase gutter space as required where sub-feed lugs, feed-through lugs, gutter taps, or oversized lugs are provided.
  - 3. Fronts:
    - a. Fronts for Surface-Mounted Enclosures: Same dimensions as boxes.
    - b. Fronts for Flush-Mounted Enclosures: Overlap boxes on all sides to conceal rough opening.
  - 4. Lockable Doors: All locks keyed alike unless otherwise indicated.
- I. Future Provisions: Prepare all unused spaces for future installation of devices including bussing, connectors, mounting hardware and all other required provisions.
- J. Surge Protective Devices: Where factory-installed, internally mounted surge protective devices are provided in accordance with Section 26 4300, list and label panelboards as a complete assembly including surge protective device.
- K. Panelboard Contactors: Where panelboard contactors are indicated, provide electrically operated, mechanically held magnetic contactor complying with NEMA ICS 2.
  - 1. Ampere Rating: Not less than ampere rating of panelboard bus.
  - 2. Short Circuit Current Rating: Not less than the panelboard short circuit current rating.
  - 3. Coil Voltage: As required for connection to control system indicated.
- L. Ground Fault Protection: Where ground-fault protection is indicated, provide system listed and labeled as complying with UL 1053.
  - 1. Where electronic circuit breakers equipped with integral ground fault protection are used, provide separate neutral current sensor where applicable.

- 2. Where accessory ground fault sensing and relaying equipment is used, equip companion overcurrent protective devices with ground-fault shunt trips.
  - a. Use zero sequence ground fault detection method unless otherwise indicated.
  - b. Provide test panel and field-adjustable ground fault pick-up and delay settings.
- M. Multi-Section Panelboards: Provide enclosures of the same height, with feed-through lugs or sub-feed lugs and feeders as indicated or as required to interconnect sections.
- N. Load centers are not acceptable.
- O. Provide the following features and accessories where indicated or where required to complete installation:
  - 1. Feed-through lugs.
  - 2. Sub-feed lugs.

### **2.03 POWER DISTRIBUTION PANELBOARDS**

- A. Description: Panelboards complying with NEMA PB 1, power and feeder distribution type, circuit breaker type, and listed and labeled as complying with UL 67; ratings, configurations and features as indicated on the drawings.
- B. Conductor Terminations:
  - 1. Main and Neutral Lug Material: Aluminum, suitable for terminating aluminum or copper conductors.
  - 2. Main and Neutral Lug Type: Mechanical.
- C. Bussing:
  - 1. Phase and Neutral Bus Material: Aluminum.
  - 2. Ground Bus Material: Aluminum.
- D. Circuit Breakers:
  - 1. Provide bolt-on type or plug-in type secured with locking mechanical restraints.
  - 2. Provide thermal magnetic circuit breakers unless otherwise indicated.
  - 3. Provide electronic trip circuit breakers where indicated.
- E. Enclosures:
  - 1. Provide surface-mounted enclosures unless otherwise indicated.
  - 2. Provide clear plastic circuit directory holder mounted on inside of door.

### **2.04 LIGHTING AND APPLIANCE PANELBOARDS**

- A. Description: Panelboards complying with NEMA PB 1, lighting and appliance branch circuit type, circuit breaker type, and listed and labeled as complying with UL 67; ratings, configurations and features as indicated on the drawings.
- B. Conductor Terminations:
  - 1. Main and Neutral Lug Material: Aluminum, suitable for terminating aluminum or copper conductors.
  - 2. Main and Neutral Lug Type: Mechanical.
- C. Bussing:
  - 1. Phase Bus Connections: Arranged for sequential phasing of overcurrent protective devices.
  - 2. Phase and Neutral Bus Material: Aluminum.
  - 3. Ground Bus Material: Aluminum.
- D. Circuit Breakers: Thermal magnetic bolt-on type unless otherwise indicated.
- E. Enclosures:
  - 1. Provide surface-mounted or flush-mounted enclosures as indicated.
  - 2. Provide clear plastic circuit directory holder mounted on inside of door.

### **2.05 OVERCURRENT PROTECTIVE DEVICES**

- A. Molded Case Circuit Breakers:

1. Description: Quick-make, quick-break, over center toggle, trip-free, trip-indicating circuit breakers listed and labeled as complying with UL 489, and complying with FS W-C-375 where applicable; ratings, configurations, and features as indicated on the drawings.
2. Interrupting Capacity:
  - a. Provide circuit breakers with interrupting capacity as required to provide the short circuit current rating indicated, but not less than:
    - 1) 10,000 rms symmetrical amperes at 240 VAC or 208 VAC.
    - 2) 14,000 rms symmetrical amperes at 480 VAC.
  - b. Fully Rated Systems: Provide circuit breakers with interrupting capacity not less than the short circuit current rating indicated.
3. Conductor Terminations:
  - a. Lug Material: Aluminum, suitable for terminating aluminum or copper conductors.
4. Thermal Magnetic Circuit Breakers: For each pole, furnish thermal inverse time tripping element for overload protection and magnetic instantaneous tripping element for short circuit protection.
5. Electronic Trip Circuit Breakers: Furnish solid state, microprocessor-based, true rms sensing trip units.
6. Multi-Pole Circuit Breakers: Furnish with common trip for all poles.
7. Provide the following circuit breaker types where indicated:
  - a. Ground Fault Circuit Interrupter (GFCI) Circuit Breakers: Listed as complying with UL 943, class A for protection of personnel.
  - b. Arc-Fault Circuit Interrupter (AFCI) Circuit Breakers: Combination type listed as complying with UL 1699.
8. Do not use tandem circuit breakers.
9. Provide multi-pole circuit breakers for multi-wire branch circuits as required by NFPA 70.
10. Provide the following features and accessories where indicated or where required to complete installation:
  - a. Shunt Trip: Provide coil voltage as required for connection to indicated trip actuator.

## **2.06 SOURCE QUALITY CONTROL**

- A. Factory test panelboards according to NEMA PB 1.

## **PART 3 EXECUTION**

### **3.01 EXAMINATION**

- A. Verify that field measurements are as indicated.
- B. Verify that the ratings and configurations of the panelboards and associated components are consistent with the indicated requirements.
- C. Verify that mounting surfaces are ready to receive panelboards.
- D. Verify that conditions are satisfactory for installation prior to starting work.

### **3.02 INSTALLATION**

- A. Perform work in accordance with NECA 1 (general workmanship).
- B. Install products in accordance with manufacturer's instructions.
- C. Install panelboards in accordance with NECA 407 and NEMA PB 1.1.
- D. Arrange equipment to provide minimum clearances in accordance with manufacturer's instructions and NFPA 70.
- E. Provide required supports in accordance with Section 26 0529.
- F. Install panelboards plumb.
- G. Install flush-mounted panelboards so that trims fit completely flush to wall with no gaps and rough opening completely covered.
- H. Mount panelboards such that the highest position of any operating handle for circuit breakers or switches does not exceed 79 inches above the floor or working platform.

- I. Mount floor-mounted power distribution panelboards on properly sized 3 inch high concrete pad constructed in accordance with Section 03 3000.
- J. Provide minimum of six spare 1 inch trade size conduits out of each flush-mounted panelboard stubbed into accessible space above ceiling and below floor.
- K. Provide grounding and bonding in accordance with Section 26 0526.
  - 1. Terminate branch circuit equipment grounding conductors on solidly bonded equipment ground bus only. Do not terminate on isolated/insulated ground bus.
  - 2. Terminate branch circuit isolated grounding conductors on isolated/insulated ground bus only. Do not terminate on solidly bonded equipment ground bus.
- L. Install all field-installed branch devices, components, and accessories.
- M. Set field-adjustable ground fault protection pickup and time delay settings as indicated.
- N. Provide filler plates to cover unused spaces in panelboards.

### **3.03 FIELD QUALITY CONTROL**

- A. Inspect and test in accordance with NETA ATS, except Section 4.
- B. Ground Fault Protection Systems: Test in accordance with manufacturer's instructions as required by NFPA 70.
- C. Test GFCI circuit breakers to verify proper operation.
- D. Test AFCI circuit breakers to verify proper operation.
- E. Test shunt trips to verify proper operation.
- F. Correct deficiencies and replace damaged or defective panelboards or associated components.

### **3.04 ADJUSTING**

- A. Adjust tightness of mechanical and electrical connections to manufacturer's recommended torque settings.
- B. Adjust alignment of panelboard fronts.
- C. Load Balancing: For each panelboard, rearrange circuits such that the difference between each measured steady state phase load does not exceed 20 percent and adjust circuit directories accordingly. Maintain proper phasing for multi-wire branch circuits.

**END OF SECTION**





**SECTION 26 2726**  
**WIRING DEVICES**

**PART 1 GENERAL**

**1.01 SECTION INCLUDES**

- A. Wall switches.
- B. Wall dimmers.
- C. Receptacles.
- D. Wall plates.
- E. Floor box service fittings.
- F. Poke-through assemblies.

**1.02 ADMINISTRATIVE REQUIREMENTS**

- A. Coordination:
  - 1. Coordinate the placement of outlet boxes with millwork, furniture, equipment, etc. installed under other sections or by others.
  - 2. Coordinate wiring device ratings and configurations with the electrical requirements of actual equipment to be installed.
  - 3. Coordinate the placement of outlet boxes for wall switches with actual installed door swings.
  - 4. Coordinate the installation and preparation of uneven surfaces, such as split face block, to provide suitable surface for installation of wiring devices.
  - 5. Coordinate the core drilling of holes for poke-through assemblies with the work covered under other sections.
  - 6. Notify Architect of any conflicts or deviations from the contract documents to obtain direction prior to proceeding with work.
- B. Sequencing:
  - 1. Do not install wiring devices until final surface finishes and painting are complete.

**1.03 QUALITY ASSURANCE**

- A. Conform to requirements of NFPA 70.
- B. Products: Listed, classified, and labeled as suitable for the purpose intended.

**PART 2 PRODUCTS**

**2.01 WIRING DEVICE APPLICATIONS**

- A. Provide wiring devices suitable for intended use and with ratings adequate for load served.
- B. For single receptacles installed on an individual branch circuit, provide receptacle with ampere rating not less than that of the branch circuit.
- C. Provide weather resistant GFCI receptacles with specified weatherproof covers for receptacles installed outdoors or in damp or wet locations.
- D. Provide GFCI protection for receptacles installed within 6 feet of sinks.
- E. Provide GFCI protection for receptacles installed in kitchens.
- F. Provide GFCI protection for receptacles serving electric drinking fountains.
- G. Unless noted otherwise, do not use combination switch/receptacle devices.
- H. For flush floor service fittings, use tile rings for installations in tile floors.
- I. For flush floor service fittings, use carpet flanges for installations in carpeted floors.

**2.02 WIRING DEVICE FINISHES**

- A. Provide wiring device finishes as described below unless otherwise indicated.
- B. Wiring Devices, Unless Otherwise Indicated: White with white nylon wall plate.

- C. Wiring Devices Installed in Finished Spaces: White with white nylon wall plate.
- D. Wiring Devices Installed in Unfinished Spaces: Gray with galvanized steel wall plate.
- E. Wiring Devices Installed in Wet or Damp Locations: White with specified weatherproof cover.
- F. Surge Protection Receptacles: Blue.
- G. Wiring Devices Connected to Emergency Power: Red with red nylon wall plate.

### **2.03 WALL SWITCHES**

- A. Wall Switches - General Requirements: AC only, quiet operating, general-use snap switches with silver alloy contacts, complying with NEMA WD 1 and NEMA WD 6, and listed as complying with UL 20 and where applicable, FS W-S-896; types as indicated on the drawings.
  - 1. Wiring Provisions: Terminal screws for side wiring and screw actuated binding clamp for back wiring with separate ground terminal screw.
- B. Standard Wall Switches: Industrial specification grade, 20 A, 120/277 V with standard toggle type switch actuator and maintained contacts; single pole single throw, double pole single throw, three way, or four way as indicated on the drawings.

### **2.04 WALL DIMMERS**

- A. Wall Dimmers - General Requirements: Solid-state with continuous full-range even control following square law dimming curve, integral radio frequency interference filtering, power failure preset memory, air gap switch accessible without removing wall plate, complying with NEMA WD 1 and NEMA WD 6, and listed as complying with UL 1472; types and ratings suitable for load controlled as indicated on the drawings.

### **2.05 RECEPTACLES**

- A. Receptacles - General Requirements: Self-grounding, complying with NEMA WD 1 and NEMA WD 6, and listed as complying with UL 498, and where applicable, FS W-C-596; types as indicated on the drawings.
  - 1. Wiring Provisions: Terminal screws for side wiring or screw actuated binding clamp for back wiring with separate ground terminal screw.
  - 2. NEMA configurations specified are according to NEMA WD 6.

### **2.06 WALL PLATES**

- A. Wall Plates: Comply with UL 514D.
  - 1. Configuration: One piece cover as required for quantity and types of corresponding wiring devices.
  - 2. Screws: Metal with slotted heads finished to match wall plate finish.
- B. Nylon Wall Plates: Smooth finish, high-impact thermoplastic.
- C. Weatherproof Covers for Damp Locations: Gasketed, cast aluminum, with self-closing hinged cover and corrosion-resistant screws; listed as suitable for use in wet locations with cover closed.
- D. Weatherproof Covers for Wet Locations: Gasketed, cast aluminum, with hinged lockable cover and corrosion-resistant screws; listed as suitable for use in wet locations while in use with attachment plugs connected and identified as extra-duty type.

### **2.07 POKE-THROUGH ASSEMBLIES**

- A. Description: Assembly comprising floor service fitting, poke-through component, fire stops and smoke barriers, and junction box for conduit termination; fire rating listed to match fire rating of floor and suitable for floor thickness where installed.

## **PART 3 EXECUTION**

### **3.01 EXAMINATION**

- A. Verify that field measurements are as indicated.
- B. Verify that outlet boxes are installed in proper locations and at proper mounting heights and are properly sized to accommodate devices and conductors in accordance with NFPA 70.

- C. Verify that wall openings are neatly cut and will be completely covered by wall plates.
- D. Verify that final surface finishes are complete, including painting.
- E. Verify that branch circuit wiring installation is completed, tested, and ready for connection to wiring devices.
- F. Verify that conditions are satisfactory for installation prior to starting work.

### 3.02 PREPARATION

- A. Provide extension rings to bring outlet boxes flush with finished surface.
- B. Clean dirt, debris, plaster, and other foreign materials from outlet boxes.

### 3.03 INSTALLATION

- A. Perform work in accordance with NECA 1 (general workmanship) and, where applicable, NECA 130, including mounting heights specified in those standards unless otherwise indicated.
- B. Coordinate locations of outlet boxes provided under Section 26 0533.16 as required for installation of wiring devices provided under this section.
  - 1. Mounting Heights: Unless otherwise indicated, as follows:
    - a. Wall Switches: 48 inches above finished floor.
    - b. Receptacles: 18 inches above finished floor or 6 inches above counter.
  - 2. Orient outlet boxes for vertical installation of wiring devices unless otherwise indicated.
  - 3. Where multiple receptacles, wall switches, or wall dimmers are installed at the same location and at the same mounting height, gang devices together under a common wall plate.
  - 4. Locate wall switches on strike side of door with edge of wall plate 3 inches from edge of door frame. Where locations are indicated otherwise, notify Architect to obtain direction prior to proceeding with work.
  - 5. Locate receptacles for electric drinking fountains concealed behind drinking fountain according to manufacturer's instructions.
- C. Install wiring devices in accordance with manufacturer's instructions.
- D. Install permanent barrier between ganged wiring devices when voltage between adjacent devices exceeds 300 V.
- E. Where required, connect wiring devices using pigtails not less than 6 inches long. Do not connect more than one conductor to wiring device terminals.
- F. Connect wiring devices by wrapping conductor clockwise 3/4 turn around screw terminal and tightening to proper torque specified by the manufacturer. Where present, do not use push-in pressure terminals that do not rely on screw-actuated binding.
- G. Unless otherwise indicated, connect wiring device grounding terminal to branch circuit equipment grounding conductor and to outlet box with bonding jumper.
- H. Unless otherwise indicated, GFCI receptacles may be connected to provide feed-through protection to downstream devices. Label such devices to indicate they are protected by upstream GFCI protection.
- I. Where split-wired duplex receptacles are indicated, remove tabs connecting top and bottom receptacles.
- J. Install wiring devices plumb and level with mounting yoke held rigidly in place.
- K. Install wall switches with OFF position down.
- L. Install wall dimmers to achieve full rating specified and indicated after derating for ganging as instructed by manufacturer.
- M. Do not share neutral conductor on branch circuits utilizing wall dimmers.
- N. Install vertically mounted receptacles with grounding pole on top and horizontally mounted receptacles with grounding pole on left.

- O. Install wall plates to fit completely flush to wall with no gaps and rough opening completely covered without strain on wall plate. Repair or reinstall improperly installed outlet boxes or improperly sized rough openings. Do not use oversized wall plates in lieu of meeting this requirement.
- P. Install blank wall plates on junction boxes and on outlet boxes with no wiring devices installed or designated for future use.
- Q. Install poke-through closure plugs in each unused core holes to maintain fire rating of floor.

### **3.04 FIELD QUALITY CONTROL**

- A. See Section 01 4000 - Quality Requirements, for additional requirements.
- B. Inspect each wiring device for damage and defects.
- C. Operate each wall switch, wall dimmer, and fan speed controller with circuit energized to verify proper operation.
- D. Test each receptacle to verify operation and proper polarity.
- E. Test each GFCI receptacle for proper tripping operation according to manufacturer's instructions.
- F. Inspect each surge protection receptacle to verify surge protection is active.
- G. Correct wiring deficiencies and replace damaged or defective wiring devices.

### **3.05 ADJUSTING**

- A. Adjust devices and wall plates to be flush and level.
- B. Adjust presets for wall dimmers according to manufacturer's instructions as directed by Architect.

### **3.06 CLEANING**

- A. Clean exposed surfaces to remove dirt, paint, or other foreign material and restore to match original factory finish.

**END OF SECTION**

## SECTION 26 2813

### FUSES

#### PART 1 GENERAL

##### 1.01 SECTION INCLUDES

- A. Fuses.
- B. Spare fuse cabinet.

##### 1.02 SUBMITTALS

##### 1.03 QUALITY ASSURANCE

- A. Conform to requirements of NFPA 70.

#### PART 2 PRODUCTS

##### 2.01 APPLICATIONS

- A. Service Entrance:
  - 1. Fusible Switches up to 600 Amperes: Class RK1, time-delay.
  - 2. Fusible Switches Larger Than 600 Amperes: Class L, time-delay.
- B. Feeders:
  - 1. Fusible Switches up to 600 Amperes: Class RK1, time-delay.
  - 2. Fusible Switches Larger Than 600 Amperes: Class L, time-delay.
- C. General Purpose Branch Circuits: Class RK1, time-delay.
- D. Individual Motor Branch Circuits: Class RK1, time-delay.

##### 2.02 FUSES

- A. Provide products listed, classified, and labeled as suitable for the purpose intended.
- B. Unless specifically indicated to be excluded, provide fuses for all fusible equipment as required for a complete operating system.
- C. Provide fuses of the same type, rating, and manufacturer within the same switch.
- D. Comply with UL 248-1.
- E. Unless otherwise indicated, provide cartridge type fuses complying with NEMA FU 1, Class and ratings as indicated.
- F. Voltage Rating: Suitable for circuit voltage.
- G. Class R Fuses: Comply with UL 248-12.
- H. Class J Fuses: Comply with UL 248-8.
- I. Class L Fuses: Comply with UL 248-10.
- J. Provide the following accessories where indicated or where required to complete installation:
  - 1. Fuseholders: Compatible with indicated fuses.
  - 2. Fuse Reducers: For adapting indicated fuses to permit installation in switch designed for fuses with larger ampere ratings.

##### 2.03 SPARE FUSE CABINET

- A. Description: Wall-mounted sheet metal cabinet with shelves and hinged door with cylinder lock, suitably sized to store spare fuses and fuse pullers specified.

#### PART 3 EXECUTION

##### 3.01 EXAMINATION

- A. Verify that fuse ratings are consistent with circuit voltage and manufacturer's recommendations and nameplate data for equipment.
- B. Verify that mounting surfaces are ready to receive spare fuse cabinet.
- C. Verify that conditions are satisfactory for installation prior to starting work.

### **3.02 INSTALLATION**

- A. Do not install fuses until circuits are ready to be energized.
- B. Install fuses with label oriented such that manufacturer, type, and size are easily read.
- C. Install spare fuse cabinet where indicated.

**END OF SECTION**

**SECTION 26 2816.13**  
**ENCLOSED CIRCUIT BREAKERS**

**PART 1 GENERAL**

**1.01 SECTION INCLUDES**

- A. Enclosed circuit breakers.

**1.02 ADMINISTRATIVE REQUIREMENTS**

- A. Coordination:
  - 1. Coordinate work with other trades. Avoid placement of ductwork, piping, equipment, or other potential obstructions within dedicated equipment spaces and within working clearances for electrical equipment required by NFPA 70.
  - 2. Coordinate arrangement of electrical equipment with the dimensions and clearance requirements of the actual equipment to be installed.
  - 3. Verify with manufacturer that conductor terminations are suitable for use with the conductors to be installed.
  - 4. Notify Architect of any conflicts with or deviations from the contract documents. Obtain direction before proceeding with work.

**1.03 QUALITY ASSURANCE**

- A. Conform to requirements of NFPA 70.

**PART 2 PRODUCTS**

**2.01 ENCLOSED CIRCUIT BREAKERS**

- A. Description: Units consisting of molded case circuit breakers individually mounted in enclosures.
- B. Provide products listed, classified, and labeled as suitable for the purpose intended.
- C. Unless otherwise indicated, provide products suitable for continuous operation under the following service conditions:
  - 1. Altitude: Less than 6,600 feet.
  - 2. Ambient Temperature: Between 23 degrees F and 104 degrees F.
- D. Short Circuit Current Rating:
  - 1. Provide enclosed circuit breakers with listed short circuit current rating not less than the available fault current at the installed location indicated on the drawings.
  - 2. Listed series ratings are acceptable, except where not permitted by motor contribution according to NFPA 70.
  - 3. Label equipment utilizing series ratings as required by NFPA 70.
- E. Enclosed Circuit Breakers Used for Service Entrance: Listed and labeled as suitable for use as service equipment according to UL 869A.
- F. Conductor Terminations: Suitable for use with the conductors to be installed.
- G. Provide thermal magnetic circuit breakers unless otherwise indicated.
- H. Provide electronic trip circuit breakers where indicated.
- I. Provide insulated, groundable fully rated solid neutral assembly where a neutral connection is required, with a suitable lug for terminating each neutral conductor.
- J. Provide solidly bonded equipment ground bus in each enclosed circuit breaker, with a suitable lug for terminating each equipment grounding conductor.
- K. Enclosures: Comply with NEMA 250, and list and label as complying with UL 50 and UL 50E.
  - 1. Environment Type per NEMA 250: Unless otherwise indicated, as specified for the following installation locations:
    - a. Indoor Clean, Dry Locations: Type 1.
    - b. Outdoor Locations: Type 3R.

- L. Provide externally operable handle with means for locking in the OFF position.
- M. Ground Fault Protection: Where ground-fault protection is indicated, provide system listed and labeled as complying with UL 1053.
  - 1. Where electronic circuit breakers equipped with integral ground fault protection are used, provide separate neutral current sensor where applicable.
  - 2. Where accessory ground fault sensing and relaying equipment is used, equip companion circuit breakers with ground-fault shunt trips.
    - a. Use zero sequence ground fault detection method unless otherwise indicated.
    - b. Provide test panel and field-adjustable ground fault pick-up and delay settings.

## **2.02 MOLDED CASE CIRCUIT BREAKERS**

- A. Description: Quick-make, quick-break, over center toggle, trip-free, trip-indicating circuit breakers listed and labeled as complying with UL 489, and complying with FS W-C-375 where applicable; ratings, configurations, and features as indicated on the drawings.
- B. Interrupting Capacity:
  - 1. Provide circuit breakers with interrupting capacity as required to provide the short circuit current rating indicated, but not less than:
    - a. 10,000 rms symmetrical amperes at 240 VAC or 208 VAC.
    - b. 14,000 rms symmetrical amperes at 480 VAC.
  - 2. Fully Rated Systems: Provide circuit breakers with interrupting capacity not less than the short circuit current rating indicated.
  - 3. Series Rated Systems: Provide circuit breakers listed in combination with upstream devices to provide interrupting rating not less than the short circuit current rating indicated.
- C. Conductor Terminations:
  - 1. Lug Material: Aluminum, suitable for terminating aluminum or copper conductors.
- D. Thermal Magnetic Circuit Breakers: For each pole, furnish thermal inverse time tripping element for overload protection and magnetic instantaneous tripping element for short circuit protection.
  - 1. Provide field-adjustable magnetic instantaneous trip setting for circuit breaker frame sizes 225 amperes and larger.
- E. Electronic Trip Circuit Breakers: Furnish solid state, microprocessor-based, true rms sensing trip units.
  - 1. Provide the following field-adjustable trip response settings:
    - a. Ground fault pickup and delay where ground fault protection is indicated.
- F. Multi-Pole Circuit Breakers: Furnish with common trip for all poles.
- G. Provide the following features and accessories where indicated or where required to complete installation:
  - 1. Shunt Trip: Provide coil voltage as required for connection to indicated trip actuator.

## **PART 3 EXECUTION**

### **3.01 INSTALLATION**

- A. Install products in accordance with manufacturer's instructions.
- B. Perform work in accordance with NECA 1 (general workmanship).
- C. Arrange equipment to provide minimum clearances in accordance with manufacturer's instructions and NFPA 70.
- D. Provide required supports in accordance with Section 26 0529.
- E. Install enclosed circuit breakers plumb.
- F. Except where indicated to be mounted adjacent to the equipment they supply, mount enclosed circuit breakers such that the highest position of the operating handle does not exceed 79 inches above the floor or working platform.
- G. Provide grounding and bonding in accordance with Section 26 0526.



H. Set field-adjustable ground fault protection pickup and time delay settings as indicated.

**3.02 FIELD QUALITY CONTROL**

- A. See Section 01 4000 - Quality Requirements, for additional requirements.
- B. Inspect and test in accordance with manufacturer's instructions and NETA ATS, except Section 4.
- C. Perform inspections and tests listed in NETA ATS, Section 7.6.1.1 for circuit breakers used for service entrance and for circuit breakers larger than \_\_\_\_\_ amperes. Tests listed as optional are not required.
- D. Ground Fault Protection Systems: Test in accordance with manufacturer's instructions as required by NFPA 70.
- E. Test shunt trips to verify proper operation.
- F. Correct deficiencies and replace damaged or defective enclosed circuit breakers.

**3.03 ADJUSTING**

- A. Adjust tightness of mechanical and electrical connections to manufacturer's recommended torque settings.

**3.04 CLEANING**

- A. Clean dirt and debris from circuit breaker enclosures and components according to manufacturer's instructions.
- B. Repair scratched or marred exterior surfaces to match original factory finish.

**END OF SECTION**



**SECTION 26 2818**  
**ENCLOSED SWITCHES**

**PART 1 GENERAL**

**1.01 SECTION INCLUDES**

- A. Enclosed safety switches.

**1.02 QUALITY ASSURANCE**

- A. Conform to requirements of NFPA 70.

**PART 2 PRODUCTS**

**2.01 ENCLOSED SAFETY SWITCHES**

- A. Description: Quick-make, quick-break enclosed safety switches listed and labeled as complying with UL 98; heavy duty; ratings, configurations, and features as indicated on the drawings.
- B. Provide products listed, classified, and labeled as suitable for the purpose intended.
- C. Unless otherwise indicated, provide products suitable for continuous operation under the following service conditions:
  - 1. Altitude: Less than 6,600 feet.
  - 2. Ambient Temperature: Between -22 degrees F and 104 degrees F.
- D. Horsepower Rating: Suitable for connected load.
- E. Voltage Rating: Suitable for circuit voltage.
- F. Short Circuit Current Rating:
  - 1. Provide enclosed safety switches, when protected by the fuses or supply side overcurrent protective devices to be installed, with listed short circuit current rating not less than the available fault current at the installed location as indicated on the drawings.
  - 2. Minimum Ratings:
    - a. Switches Protected by Class H Fuses: 10,000 rms symmetrical amperes.
    - b. Heavy Duty Single Throw Switches Protected by Class R, Class J, Class L, or Class T Fuses: 200,000 rms symmetrical amperes.
    - c. Double Throw Switches Protected by Class R, Class J, or Class T Fuses: 100,000 rms symmetrical amperes.
- G. Enclosed Safety Switches Used for Service Entrance: Listed and labeled as suitable for use as service equipment according to UL 869A.
- H. Provide with switch blade contact position that is visible when the cover is open.
- I. Fuse Clips for Fusible Switches: As required to accept fuses indicated.
  - 1. Where NEMA Class R fuses are installed, provide rejection feature to prevent installation of fuses other than Class R.
- J. Conductor Terminations: Suitable for use with the conductors to be installed.
- K. Provide insulated, groundable fully rated solid neutral assembly where a neutral connection is required, with a suitable lug for terminating each neutral conductor.
- L. Provide solidly bonded equipment ground bus in each enclosed safety switch, with a suitable lug for terminating each equipment grounding conductor.
- M. Enclosures: Comply with NEMA 250, and list and label as complying with UL 50 and UL 50E.
  - 1. Environment Type per NEMA 250: Unless otherwise indicated, as specified for the following installation locations:
    - a. Indoor Clean, Dry Locations: Type 1.
    - b. Outdoor Locations: Type 3R.
- N. Provide safety interlock to prevent opening the cover with the switch in the ON position with capability of overriding interlock for testing purposes.

- O. Heavy Duty Switches:
  - 1. Comply with NEMA KS 1.
  - 2. Conductor Terminations:
    - a. Lug Material: Aluminum, suitable for terminating aluminum or copper conductors.
  - 3. Provide externally operable handle with means for locking in the OFF position, capable of accepting three padlocks.
    - a. Provide means for locking handle in the ON position where indicated.

## **PART 3 EXECUTION**

### **3.01 EXAMINATION**

- A. Verify that field measurements are as indicated.
- B. Verify that the ratings of the enclosed switches are consistent with the indicated requirements.
- C. Verify that mounting surfaces are ready to receive enclosed safety switches.
- D. Verify that conditions are satisfactory for installation prior to starting work.

### **3.02 INSTALLATION**

- A. Install products in accordance with manufacturer's instructions.
- B. Perform work in accordance with NECA 1 (general workmanship).
- C. Arrange equipment to provide minimum clearances in accordance with manufacturer's instructions and NFPA 70.
- D. Provide required supports in accordance with Section 26 0529.
- E. Install enclosed switches plumb.
- F. Except where indicated to be mounted adjacent to the equipment they supply, mount enclosed switches such that the highest position of the operating handle does not exceed 79 inches above the floor or working platform.
- G. Provide grounding and bonding in accordance with Section 26 0526.
- H. Provide fuses complying with Section 26 2813 for fusible switches as indicated or as required by equipment manufacturer's recommendations.

### **3.03 CLEANING**

- A. Clean dirt and debris from switch enclosures and components according to manufacturer's instructions.
- B. Repair scratched or marred exterior surfaces to match original factory finish.

**END OF SECTION**

**SECTION 26 2913  
ENCLOSED CONTROLLERS**

**PART 1 GENERAL**

**1.01 SECTION INCLUDES**

- A. Enclosed NEMA controllers for low-voltage (600 V and less) applications:
  - 1. Magnetic motor starters.
  - 2. General purpose contactors.
- B. Overcurrent protective devices for motor controllers, including overload relays.
- C. Control accessories:
  - 1. Auxiliary contacts.
  - 2. Pilot devices.
  - 3. Control and timing relays.
  - 4. Control power transformers.
  - 5. Control terminal blocks.

**1.02 ADMINISTRATIVE REQUIREMENTS**

- A. Coordination:
  - 1. Coordinate the work with other trades to avoid placement of ductwork, piping, equipment, or other potential obstructions within the dedicated equipment spaces and working clearances required by NFPA 70.
  - 2. Coordinate the work to provide motor controllers and associated overload relays suitable for use with the actual motors to be installed.
  - 3. Coordinate the work to provide controllers and associated wiring suitable for interface with control devices to be installed.
  - 4. Coordinate arrangement of electrical equipment with the dimensions and clearance requirements of the actual equipment to be installed.
  - 5. Verify with manufacturer that conductor terminations are suitable for use with the conductors to be installed.
  - 6. Notify Architect of any conflicts with or deviations from the contract documents. Obtain direction before proceeding with work.

**1.03 QUALITY ASSURANCE**

- A. Conform to requirements of NFPA 70.

**1.04 DELIVERY, STORAGE, AND HANDLING**

- A. Store in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.
- B. Handle carefully in accordance with manufacturer's written instructions to avoid damage to internal components, enclosure, and finish.

**PART 2 PRODUCTS**

**2.01 ENCLOSED CONTROLLERS**

- A. Provide enclosed controller assemblies consisting of all required components, control power transformers, instrumentation and control wiring, accessories, etc. as necessary for a complete operating system.
- B. Provide products listed, classified, and labeled as suitable for the purpose intended.
- C. Description: Enclosed controllers complying with NEMA ICS 2, and listed and labeled as complying with UL 60947-1 and UL 60947-4-1; ratings, configurations and features as indicated on the drawings.
- D. Short Circuit Current Rating:
  - 1. Provide controllers with listed short circuit current rating not less than the available fault current at the installed location as indicated on the drawings.

- E. Conductor Terminations: Suitable for use with the conductors to be installed.
- F. Enclosures:
  - 1. Comply with NEMA ICS 6.
  - 2. Environment Type per NEMA 250: Unless otherwise indicated, as specified for the following installation locations:
    - a. Indoor Clean, Dry Locations: Type 1 or Type 12.
    - b. Outdoor Locations: Type 3R or Type 4.
  - 3. Finish: Manufacturer's standard unless otherwise indicated.
- G. Instrument Transformers:
  - 1. Comply with IEEE C57.13.
  - 2. Select suitable ratio, burden, and accuracy as required for connected devices.
  - 3. Current Transformers: Connect secondaries to shorting terminal blocks.
  - 4. Potential Transformers: Include primary and secondary fuses with disconnecting means.
- H. Magnetic Motor Starters: Combination type unless otherwise indicated.
  - 1. Combination Magnetic Motor Starters: NEMA ICS 2, Class A combination motor controllers with magnetic contactor(s), externally operable disconnect and overload relay(s).
  - 2. Configuration: Full-voltage non-reversing unless otherwise indicated.
  - 3. Disconnects: Circuit breaker type.
    - a. Circuit Breakers: Motor circuit protectors (magnetic-only) unless otherwise indicated or required.
    - b. Provide externally operable handle with means for locking in the OFF position. Provide safety interlock to prevent opening the cover with the disconnect in the ON position with capability of overriding interlock for testing purposes.
    - c. Provide auxiliary interlock for disconnection of external control power sources where applicable.
  - 4. Overload Relays: Bimetallic thermal type unless otherwise indicated.
- I. General Purpose Contactors: Combination type unless otherwise indicated.
  - 1. Combination Contactors: NEMA ICS 2, Class A combination controllers with magnetic contactor(s) and externally operable disconnect, but without integral overload relay(s).
  - 2. Configuration: Full-voltage non-reversing unless otherwise indicated.
  - 3. Disconnects: Circuit breaker type.
    - a. Circuit Breakers: Thermal magnetic unless otherwise indicated or required.
    - b. Provide externally operable handle with means for locking in the OFF position. Provide safety interlock to prevent opening the cover with the disconnect in the ON position with capability of overriding interlock for testing purposes.
    - c. Provide auxiliary interlock for disconnection of external control power sources where applicable.

## 2.02 OVERCURRENT PROTECTIVE DEVICES

- A. Overload Relays:
  - 1. Provide overload relays and, where applicable, associated current elements/heaters, selected according to actual installed motor nameplate data, in accordance with manufacturer's recommendations and NFPA 70; include consideration for motor service factor and ambient temperature correction, where applicable.
  - 2. Inverse-Time Trip Class Rating: Class 20 unless otherwise indicated or required.
  - 3. Trip-free operation.
  - 4. Visible trip indication.
  - 5. Resettable.
    - a. Employ manual reset unless otherwise indicated.
    - b. Do not employ automatic reset with two-wire control.
  - 6. Bimetallic Thermal Overload Relays:
    - a. Interchangeable current elements/heaters.

- b. Adjustable trip; plus/minus 10 percent of nominal, minimum.
  - c. Trip test function.
- 7. Solid-State Overload Relays:
  - a. Adjustable full load current.
  - b. Phase loss protection.
  - c. Phase imbalance protection.
  - d. Ambient temperature insensitive.
  - e. Thermal memory.
  - f. Trip test function.
  - g. Provide isolated alarm contact.
- B. Fusible Disconnect Switches:
  - 1. Description: Quick-make, quick-break, dead-front fusible switch units complying with NEMA KS 1, and listed and labeled as complying with UL 98; ratings, configurations, and features as indicated on the drawings.
  - 2. Fuse Clips: As required to accept indicated fuses.
  - 3. Provide externally operable handle with means for locking in the OFF position. Provide means for locking switch cover in the closed position. Provide safety interlock to prevent opening the cover with the switch in the ON position with capability of overriding interlock for testing purposes.
- C. Circuit Breakers:
  - 1. Interrupting Capacity (not applicable to motor circuit protectors):
    - a. Provide circuit breakers with interrupting capacity as required to provide the short circuit current rating indicated, but not less than specified minimum requirements.
    - b. Fully Rated Systems: Provide circuit breakers with interrupting capacity not less than the short circuit current rating indicated.
  - 2. Motor Circuit Protectors:
    - a. Description: Instantaneous-trip circuit breakers furnished with magnetic instantaneous tripping elements for short circuit protection, but not with thermal inverse time tripping elements for overload protection; UL 489 recognized only for use as part of a listed combination motor controller with overload protection; ratings, configurations, and features as indicated on the drawings.
    - b. Provide field-adjustable magnetic instantaneous trip setting.
    - c. Provide the following features and accessories where indicated or where required to complete installation:
      - 1) Shunt Trip: Provide coil voltage as required for connection to indicated trip actuator.
      - 2) Pad-Lock Provision: For locking circuit breaker handle in OFF position.
      - 3) Auxiliary Switch: SPDT switch suitable for connection to system indicated for indicating when circuit breaker has tripped or been turned off.
      - 4) Undervoltage Release: For tripping circuit breaker upon predetermined drop in coil voltage with field-adjustable time delay to prevent nuisance tripping.
      - 5) Alarm Switch: SPDT switch suitable for connection to system indicated for indicating when circuit breaker has tripped.
  - 3. Molded Case Circuit Breakers:
    - a. Description: Quick-make, quick-break, over center toggle, trip-free, trip-indicating circuit breakers; listed and labeled as complying with UL 489; ratings, configurations, and features as indicated on the drawings.
      - 1) Provide thermal magnetic circuit breakers unless otherwise indicated.
    - b. Thermal Magnetic Circuit Breakers: For each pole, furnish thermal inverse time tripping element for overload protection and magnetic instantaneous tripping element for short circuit protection.
    - c. Provide the following features and accessories where indicated or where required to complete installation:

- 1) Shunt Trip: Provide coil voltage as required for connection to indicated trip actuator.
- 2) Pad-Lock Provision: For locking circuit breaker handle in OFF position.
- 3) Auxiliary Switch: SPDT switch suitable for connection to system indicated for indicating when circuit breaker has tripped or been turned off.
- 4) Undervoltage Release: For tripping circuit breaker upon predetermined drop in coil voltage with field-adjustable time delay to prevent nuisance tripping.
- 5) Alarm Switch: SPDT switch suitable for connection to system indicated for indicating when circuit breaker has tripped.

### **2.03 CONTROL ACCESSORIES**

- A. Auxiliary Contacts:
  1. Comply with NEMA ICS 5.
  2. Provide number and type of contacts indicated or required to perform necessary functions, including holding (seal-in) circuit and interlocking, plus one normally open (NO) and one normally closed (NC) spare contact for each magnetic motor starter, minimum.
- B. Pilot Devices:
  1. Comply with NEMA ICS 5; heavy-duty type.
  2. Pushbuttons: Unless otherwise indicated, provide momentary, non-illuminated type with flush button operator; normally open or normally closed as indicated or as required.
  3. Selector Switches: Unless otherwise indicated, provide maintained, non-illuminated type with knob operator; number of switch positions as indicated or as required.
  4. Indicating Lights: Push-to-test type unless otherwise indicated.
  5. Provide LED lamp source for indicating lights and illuminated devices.
- C. Control and Timing Relays:
  1. Comply with NEMA ICS 5.
  2. Provide number and type of relays indicated or required to perform necessary functions.
- D. Control Power Transformers:
  1. Size to accommodate burden of contactor coil(s) and all connected auxiliary devices, plus \_\_\_\_\_ VA spare capacity.
  2. Include primary and secondary fuses.

## **PART 3 EXECUTION**

### **3.01 EXAMINATION**

- A. Verify that field measurements are as indicated.
- B. Verify that ratings of enclosed controllers are consistent with the indicated requirements.
- C. Verify that mounting surfaces are ready to receive enclosed controllers.
- D. Verify that conditions are satisfactory for installation prior to starting work.

### **3.02 INSTALLATION**

- A. Install products in accordance with manufacturer's instructions.
- B. Install controllers in accordance with NECA 1 (general workmanship).
- C. Arrange equipment to provide minimum clearances in accordance with manufacturer's instructions and NFPA 70.
- D. Provide required support and attachment components in accordance with Section 26 0529.
- E. Install enclosed controllers plumb and level.
- F. Provide grounding and bonding in accordance with Section 26 0526.
- G. Install all field-installed devices, components, and accessories.
- H. Provide fuses complying with Section 26 2813 for fusible switches as indicated.
- I. Where accessories are not self-powered, provide control power source as indicated or as required to complete installation.



- J. Set field-adjustable controllers and associated components according to installed motor requirements, in accordance with manufacturer's recommendations and NFPA 70.
- K. Set field-adjustable circuit breaker tripping function settings as indicated.

**3.03 PROTECTION**

- A. Protect installed enclosed controllers from subsequent construction operations.

**END OF SECTION**



**SECTION 26 3213  
ENGINE GENERATORS**

**PART 1 GENERAL**

**1.01 SECTION INCLUDES**

- A. Packaged engine generator system and associated components and accessories:
  - 1. Engine and engine accessory equipment.
  - 2. Alternator (generator).
  - 3. Generator set control system.
  - 4. Generator set enclosure.

**1.02 SUBMITTALS**

- A. Product Data: Provide manufacturer's standard catalog pages and data sheets for each product, including ratings, configurations, dimensions, finishes, weights, service condition requirements, and installed features. Include alternator starting capabilities, engine fuel consumption rates, and cooling, combustion air, and exhaust requirements.
  - 1. Include generator set sound level test data.
- B. Shop Drawings: Include dimensioned plan views and sections indicating locations of system components, required clearances, and field connection locations. Include system interconnection schematic diagrams showing all factory and field connections.
- C. Manufacturer's factory emissions certification.
- D. Source quality control test reports.
- E. Provide NFPA 110 required documentation from manufacturer where requested by authorities having jurisdiction, including but not limited to:
  - 1. Certified prototype tests.
  - 2. Torsional vibration compatibility certification.
  - 3. NFPA 110 compliance certification.
  - 4. Certified rated load test at rated power factor.
- F. Manufacturer's detailed field testing procedures.
- G. Field quality control test reports.

**1.03 QUALITY ASSURANCE**

- A. Comply with the following:
  - 1. NFPA 70 (National Electrical Code).
  - 2. NFPA 110 (Standard for Emergency and Standby Power Systems); meet requirements for Level 1 system.
  - 3. NFPA 37 (Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines).
- B. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

**1.04 DELIVERY, STORAGE, AND HANDLING**

- A. Receive, inspect, handle, and store generator sets in accordance with manufacturer's instructions and NECA/EGSA 404.
- B. Store in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.
- C. Handle carefully in accordance with manufacturer's instructions to avoid damage to generator set components, enclosure, and finish.

**1.05 FIELD CONDITIONS**

- A. Maintain field conditions within manufacturer's required service conditions during and after installation.

## **PART 2 PRODUCTS**

### **2.01 MANUFACTURERS**

- A. Packaged Engine Generator Set - Basis of Design: HiPower HJW 130 T6U.
- B. Products other than basis of design are subject to compliance with specified requirements and prior approval of Engineer. By using products other than basis of design, Contractor accepts responsibility for costs associated with any necessary modifications to related work, including any design fees.

### **2.02 PACKAGED ENGINE GENERATOR SYSTEM**

- A. Provide new engine generator system consisting of all required equipment, sensors, conduit, boxes, wiring, piping, supports, accessories, system programming, etc. as necessary for a complete operating system that provides the functional intent indicated.
- B. Provide products listed, classified, and labeled as suitable for the purpose intended.
- C. System Description:
  - 1. Application: Emergency/standby.
  - 2. Configuration: Single packaged engine generator set operated independently (not in parallel).
- D. Generator Set General Requirements:
  - 1. Prototype tested in accordance with NFPA 110 for Level 1 systems.
  - 2. Factory-assembled, with components mounted on suitable base.
  - 3. List and label engine generator assembly as complying with UL 2200.
  - 4. Power Factor: Unless otherwise indicated, specified power ratings are at 0.8 power factor for three phase voltages and 1.0 power factor for single phase voltages.
  - 5. Provide suitable guards to protect personnel from accidental contact with rotating parts, hot piping, and other potential sources of injury.
  - 6. Main Line Circuit Breakers: Provide factory-installed line side connections with suitable lugs for load side connections.
- E. Service Conditions: Provide engine generator system and associated components suitable for operation under the service conditions at the installed location.
  - 1. Altitude: 9200 feet.
- F. Starting and Load Acceptance Requirements:
  - 1. Cranking Method: Cycle cranking complying with NFPA 110 (15 second crank period, followed by 15 second rest period, with cranking limiter time-out after 3 cycles), unless otherwise required.
  - 2. Cranking Limiter Time-Out: If generator set fails to start after specified cranking period, indicate overcrank alarm condition and lock-out generator set from further cranking until manually reset.
  - 3. Start Time: Capable of starting and achieving conditions necessary for load acceptance within 10 seconds (NFPA 110, Type 10).
  - 4. Maximum Load Step: Supports 100 percent of rated load in one step.
- G. Exhaust Emissions Requirements:
  - 1. Comply with federal (EPA), state, and local regulations applicable at the time of commissioning; include factory emissions certification with submittals.
  - 2. Do not make modifications affecting generator set factory emissions certification without approval of manufacturer and Engineer. Where such modifications are made, provide field emissions testing as necessary for certification.
- H. Sound Level Requirements:
  - 1. Do not exceed 75 dBA when measured at 23 feet from generator set in free field (no sound barriers) while operating at full load; include manufacturer's sound data with submittals.

## 2.03 ENGINE AND ENGINE ACCESSORY EQUIPMENT

- A. Provide engine with adequate horsepower to achieve specified power output at rated speed, accounting for alternator efficiency and parasitic loads.
- B. Engine Starting System:
  - 1. System Type: Electric, with DC solenoid-activated starting motor(s).
  - 2. Battery(s):
    - a. Battery Type: Lead-acid.
    - b. Battery Capacity: Size according to manufacturer's recommendations for achieving starting and load acceptance requirements under worst case ambient temperature; capable of providing cranking through two complete periods of cranking limiter time-outs without recharging.
    - c. Provide battery rack, cables, and connectors suitable for the supplied battery(s); size battery cables according to manufacturer's recommendations for cable length to be installed.
  - 3. Battery-Charging Alternator: Engine-driven, with integral solid-state voltage regulation.
  - 4. Battery Charger:
    - a. Provide dual rate battery charger with automatic float and equalize charging modes and minimum rating of 10 amps; suitable for maintaining the supplied battery(s) at full charge without manual intervention.
    - b. Capable of returning supplied battery(s) from fully discharged to fully charged condition within 24 hours, as required by NFPA 110 for Level 1 applications while carrying normal loads.
    - c. Recognized as complying with UL 1236.
    - d. Furnished with integral overcurrent protection; current limited to protect charger during engine cranking; reverse polarity protection.
    - e. Provide integral DC output ammeter and voltmeter with five percent accuracy.
    - f. Provide alarm output contacts as necessary for alarm indications.
  - 5. Battery Heater: Provide thermostatically controlled battery heater to improve starting under cold ambient conditions.
- C. Engine Speed Control System (Governor):
  - 1. Single Engine Generator Sets (Not Operated in Parallel): Provide electronic isochronous governor for controlling engine speed/alternator frequency.
  - 2. Frequency Regulation, Electronic Isochronous Governors: No change in frequency from no load to full load; plus/minus 0.25 percent at steady state.
- D. Engine Lubrication System:
  - 1. System Type: Full pressure, with engine-driven, positive displacement lubrication oil pump, replaceable full-flow oil filter(s), and dip-stick for oil level indication. Provide oil cooler where recommended by manufacturer.
- E. Engine Cooling System:
  - 1. System Type: Closed-loop, liquid-cooled, with unit-mounted radiator/fan and engine-driven coolant pump; suitable for providing adequate cooling while operating at full load under worst case ambient temperature.
  - 2. Fan Guard: Provide suitable guard to protect personnel from accidental contact with fan.
  - 3. Coolant Heater: Provide thermostatically controlled coolant heater to improve starting under cold ambient conditions; size according to manufacturer's recommendations for achieving starting and load acceptance requirements under worst case ambient temperature.
- F. Engine Air Intake and Exhaust System:
  - 1. Air Intake Filtration: Provide engine-mounted, replaceable, dry element filter.
  - 2. Engine Exhaust Connection: Provide suitable, approved flexible connector for coupling engine to exhaust system.

3. Exhaust Silencer: Provide critical grade or better exhaust silencer with sound attenuation not less than basis of design; select according to manufacturer's recommendations to meet sound performance requirements, where specified.

#### **2.04 ALTERNATOR (GENERATOR)**

- A. Alternator: 4-pole, 1800 rpm (60 Hz output) revolving field, synchronous generator complying with NEMA MG 1; connected to engine with flexible coupling; voltage output configuration as indicated, with reconnectable leads for 3 phase alternators.
- B. Exciter:
  1. Exciter Type: Brushless; provide permanent magnet generator (PMG) excitation system; self-excited (shunt) systems are not permitted.
  2. PMG Excitation Short-Circuit Current Support: Capable of sustaining 300 percent of rated output current for 10 seconds.
  3. Voltage Regulation (with PMG excitation): Plus/minus 0.5 percent for any constant load from no load to full load.
  4. Voltage Regulation (with shunt or PMG excitation): Plus/minus two percent for any constant load from no load to full load.
- C. Temperature Rise: Comply with UL 2200.
- D. Insulation System: NEMA MG 1, Class H; suitable for alternator temperature rise.
- E. Enclosure: NEMA MG 1, drip-proof.
- F. Total Harmonic Distortion: Not greater than five percent.
- G. Alternator Heater: Provide strip heater to prevent moisture condensation on alternator windings.

#### **2.05 GENERATOR SET CONTROL SYSTEM**

- A. Provide microprocessor-based control system for automatic control, monitoring, and protection of generator set. Include sensors, wiring, and connections necessary for functions/indications specified.
- B. Control Panel:
  1. Control Panel Mounting: Unit-mounted unless otherwise indicated; vibration isolated.
  2. Generator Set Control Functions:
    - a. Automatic Mode: Initiates generator set start/shutdown upon receiving corresponding signal from remote device (e.g. automatic transfer switch).
    - b. Manual Mode: Initiates generator set start/shutdown upon direction from operator.
    - c. Reset Mode: Clears all faults, allowing generator set restart after a shutdown.
    - d. Emergency Stop: Immediately shuts down generator set (without time delay) and prevents automatic restarting until manually reset.
    - e. Cycle Cranking: Programmable crank time, rest time, and number of cycles.
    - f. Time Delay: Programmable for shutdown (engine cooldown) and start (engine warmup).
    - g. Voltage Adjustment: Adjustable through range of plus/minus 5 percent.
  3. Generator Set Status Indications:
    - a. Voltage (Volts AC): Line-to-line, line-to-neutral for each phase.
    - b. Current (Amps): For each phase.
    - c. Frequency (Hz).
    - d. Real power (W/kW).
    - e. Reactive power (VAR/kVAR).
    - f. Apparent power (VA/kVA).
    - g. Power factor.
    - h. Duty Level: Actual load as percentage of rated power.
    - i. Engine speed (RPM).
    - j. Battery voltage (Volts DC).
    - k. Engine oil pressure.

- l. Engine coolant temperature.
  - m. Engine run time.
  - n. Generator powering load (position signal from transfer switch).
  - 4. Generator Set Protection and Warning/Shutdown Indications:
    - a. Comply with NFPA 110; configurable for NFPA 110 Level 1 or Level 2, or NFPA 99 systems including but not limited to the following protections/indications:
      - 1) Overcrank (shutdown).
      - 2) Low coolant temperature (warning).
      - 3) High coolant temperature (warning).
      - 4) High coolant temperature (shutdown).
      - 5) Low oil pressure (warning).
      - 6) Low oil pressure (shutdown).
      - 7) Overspeed (shutdown).
      - 8) Low fuel level (warning).
      - 9) Low coolant level (warning/shutdown).
      - 10) Generator control not in automatic mode (warning).
      - 11) High battery voltage (warning).
      - 12) Low cranking voltage (warning).
      - 13) Low battery voltage (warning).
      - 14) Battery charger failure (warning).
    - b. In addition to NFPA 110 requirements, provide the following protections/indications:
      - 1) High AC voltage (shutdown).
      - 2) Low AC voltage (shutdown).
      - 3) High frequency (shutdown).
      - 4) Low frequency (shutdown).
      - 5) Overcurrent (shutdown).
      - 6) Fuel tank leak (warning), where applicable.
    - c. Provide contacts for local and remote common alarm.
    - d. Provide lamp test function that illuminates all indicator lamps.
  - 5. Other Control Panel Features:
    - a. Event log.
    - b. Communications Capability: Compatible with system indicated. Provide all accessories necessary for proper interface.
    - c. Remote monitoring capability via PC.
- C. Remote Annunciator:
- 1. Remote Annunciator Mounting: Wall-mounted; Provide flush-mounted annunciator for finished areas and surface-mounted annunciator for non-finished areas unless otherwise indicated.
  - 2. Generator Set Status Indications:
    - a. Generator powering load (via position signal from transfer switch).
    - b. Communication functional.
  - 3. Generator Set Warning/Shutdown Indications:
    - a. Comply with NFPA 110 for Level 1 systems including but not limited to the following indications:
      - 1) Overcrank (shutdown).
      - 2) Low coolant temperature (warning).
      - 3) High coolant temperature (warning).
      - 4) High coolant temperature (shutdown).
      - 5) Low oil pressure (warning).
      - 6) Low oil pressure (shutdown).
      - 7) Overspeed (shutdown).
      - 8) Low fuel level (warning).
      - 9) Low coolant level (warning/shutdown).

- 10) Generator control not in automatic mode (warning).
  - 11) High battery voltage (warning).
  - 12) Low cranking voltage (warning).
  - 13) Low battery voltage (warning).
  - 14) Battery charger failure (warning).
  - b. Provide audible alarm with silence function.
  - c. Provide lamp test function that illuminates all indicator lamps.
- D. Remote Emergency Stop: Provide approved red, mushroom style remote emergency stop button where indicated or required by authorities having jurisdiction.

## **2.06 GENERATOR SET ENCLOSURE**

- A. Enclosure Type: Sound attenuating, weather protective.
- B. Enclosure Material: Steel or aluminum.
- C. Hardware Material: Stainless steel.
- D. Color: Manufacturer's standard.
- E. Access Doors: Lockable, with all locks keyed alike.
- F. Openings: Designed to prevent bird/rodent entry.
- G. External Drains: Extend oil and coolant drain lines to exterior of enclosure for maintenance service.
- H. Sound Attenuating Enclosures: Line enclosure with non-hydroscopic, self-extinguishing sound-attenuating material.
- I. Exhaust Silencers: Where exhaust silencers are mounted within enclosure in main engine compartment, insulate silencer to minimize heat dissipation as necessary for operation at rated load under worst case ambient temperature.

## **2.07 SOURCE QUALITY CONTROL**

- A. See Section 01 4000 - Quality Requirements, for additional requirements.
- B. Perform production tests on generator sets at factory to verify operation and performance characteristics prior to shipment. Include certified test report with submittals.
- C. Generator Set production testing to include, at a minimum:
  - 1. Operation at rated load and rated power factor.
  - 2. Single step load pick-up.
  - 3. Transient and steady state voltage and frequency performance.
  - 4. Operation of safety shutdowns.

## **PART 3 EXECUTION**

### **3.01 EXAMINATION**

- A. Verify that field measurements are as indicated.
- B. Verify that the ratings and configurations of generator sets and auxiliary equipment are consistent with the indicated requirements.
- C. Verify that rough-ins for field connections are in the proper locations.
- D. Verify that mounting surfaces are ready to receive equipment.
- E. Verify that conditions are satisfactory for installation prior to starting work.

### **3.02 INSTALLATION**

- A. Perform work in accordance with NECA 1 (general workmanship).
- B. Install products in accordance with manufacturer's instructions.
- C. Install generator sets and associated accessories in accordance with NECA/EGSA 404.
- D. Arrange equipment to provide minimum clearances and required maintenance access.



- E. Unless otherwise indicated, mount generator set on properly sized 6 inch high concrete pad constructed in accordance with Section 03 3000. Provide suitable vibration isolators, where not factory installed.
- F. Provide required support and attachment in accordance with Section 26 0529.
- G. Use manufacturer's recommended oil and coolant, suitable for the worst case ambient temperatures.
- H. Provide engine exhaust piping in accordance with Section 23 5100, where not factory installed.
  - 1. Include piping expansion joints, piping insulation, thimble, condensation trap/drain, rain cap, hangers/supports, etc. as indicated or as required.
  - 2. Do not exceed manufacturer's maximum back pressure requirements.
- I. Install exhaust silencer in accordance with Section 23 5100, where not factory installed.
- J. Provide grounding and bonding in accordance with Section 26 0526.
- K. Identify system wiring and components in accordance with Section 26 0553.

### **3.03 FIELD QUALITY CONTROL**

- A. See Section 01 4000 - Quality Requirements, for additional requirements.
- B. Provide services of a manufacturer's authorized representative to prepare and start systems and perform inspection and testing. Include manufacturer's detailed testing procedures and field reports with submittals.
- C. Notify Owner and Architect at least two weeks prior to scheduled inspections and tests.
- D. Notify authorities having jurisdiction and comply with their requirements for scheduling inspections and tests and for observation by their personnel.
- E. Provide all equipment, tools, and supplies required to accomplish inspection and testing, including load bank and fuel.
- F. Preliminary inspection and testing to include, at a minimum:
  - 1. Inspect each system component for damage and defects.
  - 2. Verify tightness of mechanical and electrical connections are according to manufacturer's recommended torque settings.
  - 3. Check for proper oil and coolant levels.
- G. Prepare and start system in accordance with manufacturer's instructions.
- H. Perform acceptance test in accordance with NFPA 110.
- I. Inspection and testing to include, at a minimum:
  - 1. Verify compliance with starting and load acceptance requirements.
  - 2. Verify voltage and frequency; make required adjustments as necessary.
  - 3. Verify phase sequence.
  - 4. Verify control system operation, including safety shutdowns.
  - 5. Verify operation of auxiliary equipment and accessories (e.g. battery charger, heaters, etc.).
- J. Provide field emissions testing where necessary for certification.
- K. Correct defective work, adjust for proper operation, and retest until entire system complies with contract documents.
- L. Submit detailed reports indicating inspection and testing results and corrective actions taken.

### **3.04 CLEANING**

- A. Clean exposed surfaces to remove dirt, paint, or other foreign material and restore to match original factory finish.

### **3.05 PROTECTION**

- A. Protect installed engine generator system from subsequent construction operations.

**END OF SECTION**



**SECTION 26 3353**  
**STATIC UNINTERRUPTIBLE POWER SUPPLY**

**PART 1 GENERAL**

**1.01 SUBMITTALS**

- A. Shop Drawings: Indicate electrical characteristics and connection requirements. Provide battery rack dimensions; battery type, size, dimensions, and weight; detailed equipment outlines, weight, and dimensions; location of conduit entry and exit; single-line diagram indicating metering, control, and external wiring requirements; heat rejection and air flow requirements.
- B. Product Data: Provide catalog sheets and technical data sheets to indicate physical data and electrical performance, electrical characteristics, and connection requirements.

**1.02 QUALITY ASSURANCE**

- A. Conform to requirements of NFPA 70.

**1.03 DELIVERY, STORAGE, AND HANDLING**

- A. Protect equipment from extreme temperature and humidity by storing in a conditioned space.
- B. Protect equipment from dust and debris by wrapping unit in dust tight cover and storing away from construction activity.
- C. Deliver batteries no sooner than 7 days before charging.

**1.04 WARRANTY**

- A. Provide five year warranty including coverage for batteries.

**PART 2 PRODUCTS**

**2.01 UNINTERRUPTIBLE POWER SUPPLY (UPS) SYSTEMS**

- A. System Configuration: Non-redundant type with reverse transfer. Designed for capacity expansion by addition of parallel modules in field with minimum downtime.
- B. Components:
  - 1. Battery.
  - 2. Rectifier/charger to maintain battery charge and to provide input to inverter when utility power is available.
  - 3. Inverter to provide power to load during normal operation.
  - 4. Static switch to transfer load automatically and without disturbance between inverter and utility power.
  - 5. Input and output isolation transformers and filters to provide appropriate isolation and disturbance attenuation.
  - 6. Monitors, sensors, and control circuits.
- C. Design Standards: IEEE 519 and NEMA PE 1.
- D. Converter (rectifier): Incoming power shall be filtered and converted to DC by a sine-wave rectifier. The DC power is then processed by a high-frequency converter to supply power to the inverter. The Converter corrects the input power factor to 0.99 and draws sinusoidal current (with less than 5% THD) from the utility. In the event of utility failure, the converter shall be supplied power without interruption from the internal of external batteries.
  - 1. Overload Capacity: The converter shall be capable of supplying up to 150% of rated load for at least 5 seconds if no bypass is available.
- E. Inverter: The inverter converts the DC Power to regulated AC Power for critical loads.
  - 1. Output Voltage: The inverter output voltage is specified in section 2.03.

2. Voltage Regulation: The inverter steady state voltage regulation is +/- 1% phase to neutral, 2% phase to phase. Dynamic regulation meets class 1 performance of IEC62040-3.
  3. Frequency Control: The inverter steady state frequency regulation is +/-0.005 Hz free running in steady state. UPS is synchronized to mains in normal operation.
- F. Batteries: The batteries shall be sealed, lead acid, maintenance-free, high-rate discharge cells. They will be kept fully charged by the battery charger. They have a 3-year float service life @ 25° C.
  - G. Battery Charger: The battery charger is responsible for charging the battery and maintaining full battery charge when AC is applied to the UPS.
  - H. Automatic Bypass (Static bypass): The UPS shall provide an alternate path to the commercial AC or generator source in case of an overload, load fault or internal UPS failure. This input must match the output in voltage, frequency, and grounding in order to properly utilize this feature.
  - I. User Interface Panel: The UPS shall provide a user-friendly interface panel, which allows the user to: change operating modes, set system parameters, check alarm logs, etc. This LCD display should have back light and languages consisting of English and the number of optional local languages.
  - J. Serial (RS-232) Communication Interface: A 9-pin sub-D connector shall provide capability for communicating with manufacture-supplied software package. The UPS shall also provide signals for indication of UPS general alarm.
  - K. (2) Communication card slots: The UPS shall provide (2) Communication card slots in the front of the UPS allowing for additional connectivity options, including SNMP/Web, AS400 relays, and Modus/Jbus capabilities, etc.
  - L. Remote Emergency Power Off (EPO) connection: The UPS shall provide a built-in landing for field connection of a Remote Emergency Power Off circuit. Upon initiation of the REPO circuit, the output will be de-energized and battery will be disconnected, preventing power from being delivered to the attached loads.
  - M. Disable Bypass Operation connection: If active the automatic transfer to the static bypass is prevented. Synchronization to bypass is not carried out (default).
  - N. ABM resting connection: If active the batteries are disconnected from the UPS unit. The discharge of batteries is not prevented but charging will not start.
  - O. Remote ON/OFF connection: If active the UPS output turns off regardless of mode of operation. Auxiliary power, communications and rectifier/battery charger shall remain functional.
  - P. External Bypass connection: If active the UPS is forced to static bypass operation regardless of the bypass status.

- Q. External Battery Breaker Status: If active the UPS knows that the batteries are connected.

## 2.02 SYSTEM RATINGS AND OPERATING CHARACTERISTICS

- A. System Continuous Rating: As indicated on drawings, over entire battery voltage range at specified power factor. Maintain output voltage within specified limits at any load from full load to no-load.
1. Input Voltage Operation Range
    - a. 120/240VAC 180 degree phase displacement
  2. Input Frequency
    - a. 45 to 65 Hz
    - b. auto sensing
  3. Input power factor is 0.99
  4. Input Current Distortion: 2% THD maximum at full rated linear load.
  5. Inrush Current:
    - <2x branch rating without input transformer
    - <5x branch rating with input transformer
  6. Surge Protection:
    - Line to Line 180J
    - Line to Ground 450J
  7. Nominal Output Voltage
    - a. 200/100, 220/110, 240/120 VAC, 180-degree phase displacement
  8. Voltage regulation: +/-3% of selected output voltage in steady state
  9. Transient Voltage Response:
    - Meets class 1 performance of IEC62040-3
  10. Voltage THD:
    - 2% Total Harmonic Distortion (THD) maximum phase to neutral into a maximum rated linear load (5% phase to phase)
    - 5% THD maximum phase to neutral into a maximum rated non-linear load (7% phase to phase)
  11. Nominal Frequency: 50 or 60 Hz selectable
  12. Frequency Regulation:
    - 50/60 Hz +/- 0.5 to +/- 3.0 Hz selectable, synchronized to mains, +/- 0.005 Hz free running single units.
    - +/- 0.15 Hz parallel units.
    - Slew rate selectable to 1.0, 2.0, 3.0 Hz/s for single units, < 0.5 Hz/s parallel units. Generator Mode (6 / 7.5 Hz/s) for single units selectable through software parameters that can be configured via LCD and service PC interface
  13. Output Current: Maximum output current (at nominal output voltage) for the UPS shall be:
    - a. 10 kVA system: 42A @ 240V
    - b. 12 kVA system: 50A @ 240V
    - c. 15 kVA system: 63A @ 240V
  14. Current Overload Capability without bypass:
    - a. 150% for 5 seconds

b. 220% for 300 ms

15. Bypass:

- a. bypass shall provide an alternate path to power in the case of overload, inverter failure or other UPS failure.
- b. Maintenance Bypass can be utilized with the UPS to all servicing of the UPS.
- c. Transfer time to and from any internal bypass shall be no-break.

16. Efficiency:

- a. Typical of >89% while in normal mode.

B. Modes of Operation: The UPS shall operate as a double conversion UPS with the following operations modes:

1. Normal

During the Normal or Double Conversion Mode the rectifier shall derive power as needed from the commercial AC utility or generator source and supply filtered and regulated DC power to the on-line inverter. The inverter shall convert the DC power to highly regulated and filtered AC power for the critical loads.

2. Battery

Upon failure of the AC input source, the critical load must continue being supplied by the inverter without any switching. The inverter must obtain its power from the battery. There must be no interruption in power to the critical load upon failure or restoration of the AC input source.

3. Recharge

Upon restoration of the AC input source, the rectifier/battery charger must recharge the battery. The inverter shall with no interruption in power regulate the power to the critical load.

4. Bypass

The static bypass switch has to be used for transferring the critical load to mains supply without interruption. Automatic re-transfer to normal operation must also be accomplished with no interruption in power to the critical load. The static bypass switch has to be capable of manual operation.

5. External maintenance bypass

The external maintenance bypass switch is preferred but minimum need is the integral maintenance bypass if no such item in the system. It is used for supplying the load directly from the mains supply, while the UPS is isolated for maintenance.

## 2.03 BATTERY

- A. Battery Type: Valve Regulated Lead Acid (VRLA), minimum 3-year float service life at 25 degrees C.
- B. UPS Holdover Time (Runtime): Each UPS system, consisting of a minimum of two battery strings (consisting of 32 battery blocks) for each power modules shall have a minimum holdover time of 4.6 minutes, depending on kVA rating. See product manual for detailed information.
- C. Extended Holdover Time (Runtime): Each UPS system shall have capability for addition of extra matching battery cabinets (in two cabinet sizes) to increase the total holdover time. Please refer

to datasheet for a list of runtimes. The battery times listed are approximate and may vary depending on load configuration and battery charge.

**D. Battery Recharge Time:**

1. Base UPS System consisting of 2 battery strings will have a recharge time of max. 1.45 hours to 95% usable capacity @ nominal line after a full load discharge (15kVA).

**E. Bus Voltage:** Nominal bus voltage is 192 VDC. Each string consists of 16 battery blocks in series with 9 Ah capacity.

**F. Battery Protection:**

1. Short Circuit Protection: Over-current protection shall protect the batteries from all short circuit fault conditions.
2. Battery Module Protection: Internal Battery circuit breaker shall be provided.
3. Under-voltage Protection:
  - a. Inverter cutoff voltage: Battery operation shall be terminated when the battery voltage drops to the 1.7 VPC set point.
  - b. Protective shutdown voltage: Inverter shall shutdown after 1 min when the battery voltage drops below 1.7 VPC volts-per-cell typical.
4. Over-voltage Protection: If the UPS systems battery bus voltage exceeds the preset set point then the UPS will disable charger and alarm a high battery condition.

**G. Advanced Battery Management:**

1. Battery recharge: After recharging batteries to full capacity, the charger will enter the rest mode to increase the battery lifetime according the ABM cycle. Hence, continuous float charging of the battery shall not be allowed.  
The active battery charger states are constant-current (charge mode), constant-voltage (float mode) and no-charge (rest mode).
2. Battery Runtime Monitoring: UPS shall monitor batteries and provide status to end user of battery runtime via front panel, serial communications, or both. Runtime calculations to be based on load demand and analysis of battery health.
3. Battery Health Monitoring: UPS shall periodically test and monitor battery health and provide warnings visually, audibly and/or serially when battery capacity falls below 80% of original capacity. Battery testing may also be user initiated via front panel or serial communications.

## **PART 3 EXECUTION**

### **3.01 INSTALLATION**

- A. Install in accordance with manufacturer's instructions.

**END OF SECTION**





**SECTION 26 3600  
TRANSFER SWITCHES**

**PART 1 GENERAL**

**1.01 SECTION INCLUDES**

- A. Transfer switches for low-voltage (600 V and less) applications and associated accessories:
  - 1. Automatic transfer switches.
  - 2. Includes service entrance rated transfer switches.
  - 3. Includes bypass/isolation transfer switches.

**1.02 ADMINISTRATIVE REQUIREMENTS**

- A. Coordination:
  - 1. Coordinate compatibility of transfer switches to be installed with work provided under other sections or by others.
    - a. Engine Generators: See Section 26 3213.
  - 2. Coordinate the work with other trades to avoid placement of ductwork, piping, equipment, or other potential obstructions within the dedicated equipment spaces and working clearances required by NFPA 70.
  - 3. Coordinate arrangement of equipment with the dimensions and clearance requirements of the actual equipment to be installed.
  - 4. Coordinate the work with placement of supports, anchors, etc. required for mounting.
  - 5. Notify Architect of any conflicts with or deviations from the contract documents. Obtain direction before proceeding with work.

**1.03 SUBMITTALS**

- A. Product Data: Provide manufacturer's standard catalog pages and data sheets for each product, including ratings, configurations, dimensions, finishes, weights, service condition requirements, and installed features.
- B. Manufacturer's detailed field testing procedures.
- C. Maintenance contracts.

**1.04 QUALITY ASSURANCE**

- A. Comply with the following:
  - 1. NFPA 70 (National Electrical Code).
  - 2. NFPA 110 (Standard for Emergency and Standby Power Systems); meet requirements for system Level specified in Section 26 3213.
- B. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

**1.05 DELIVERY, STORAGE, AND HANDLING**

- A. Receive, inspect, handle, and store transfer switches in accordance with manufacturer's instructions.
- B. Store in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.
- C. Handle carefully in accordance with manufacturer's instructions to avoid damage to transfer switch components, enclosure, and finish.

**1.06 FIELD CONDITIONS**

- A. Maintain field conditions within manufacturer's required service conditions during and after installation.

## **PART 2 PRODUCTS**

### **2.01 TRANSFER SWITCHES**

- A. Provide complete power transfer system consisting of all required equipment, conduit, boxes, wiring, supports, accessories, system programming, etc. as necessary for a complete operating system that provides the functional intent indicated.
- B. Provide products listed, classified, and labeled as suitable for the purpose intended.
- C. Applications:
- D. Construction Type: Either "contactor type" (open contact) or "breaker type" (enclosed contact) transfer switches complying with specified requirements are acceptable.
- E. Automatic Transfer Switch:
  - 1. Transfer Switch Type: As indicated on the drawings.
  - 2. Transition Configuration: As indicated on the drawings.
  - 3. Voltage: As indicated on the drawings.
  - 4. Ampere Rating: As indicated on the drawings.
  - 5. Load Served: As indicated on the drawings.
- F. Comply with NEMA ICS 10 Part 1, and list and label as complying with UL 1008 for the classification of the intended application (e.g. emergency, optional standby).
- G. Do not use double throw safety switches or other equipment not specifically designed for power transfer applications and listed as transfer switch equipment.
- H. Load Classification: Classified for total system load (any combination of motor, electric discharge lamp, resistive, and tungsten lamp loads with tungsten lamp loads not exceeding 30 percent of the continuous current rating) unless otherwise indicated or required.
- I. Switching Methods:
  - 1. Open Transition:
    - a. Provide break-before-make transfer without a neutral position that is not connected to either source, and with interlocks to prevent simultaneous connection of the load to both sources.
  - 2. Obtain control power for transfer operation from line side of source to which the load is to be transferred.
- J. Service Conditions: Provide transfer switches suitable for continuous operation at indicated ratings under the service conditions at the installed location.
- K. Enclosures:
  - 1. Environment Type per NEMA 250: Unless otherwise indicated, as specified for the following installation locations:
  - 2. Finish: Manufacturer's standard unless otherwise indicated.
- L. Short Circuit Current Rating:
  - 1. Withstand and Closing Rating: Provide transfer switches, when protected by the supply side overcurrent protective devices to be installed, with listed withstand and closing rating not less than the available fault current at the installed location as indicated on the drawings.
- M. Automatic Transfer Switches:
  - 1. Description: Transfer switches with automatically initiated transfer between sources; electrically operated and mechanically held.
  - 2. Control Functions:
    - a. Automatic mode.
    - b. Test Mode: Simulates failure of primary/normal source.
    - c. Voltage and Frequency Sensing:
      - 1) Undervoltage sensing for each phase of primary/normal source; adjustable dropout/pickup settings.

- 2) Undervoltage sensing for alternate/emergency source; adjustable dropout/pickup settings.
- 3) Underfrequency sensing for alternate/emergency source; adjustable dropout/pickup settings.
- d. Outputs:
  - 1) Contacts for engine start/shutdown (except where direct generator communication interface is provided).
  - 2) Auxiliary contacts; one set(s) for each switch position.
- e. Adjustable Time Delays:
  - 1) Engine generator start time delay; delays engine start signal to override momentary primary/normal source failures.
  - 2) Transfer to alternate/emergency source time delay.
  - 3) Retransfer to primary/normal source time delay.
  - 4) Engine generator cooldown time delay; delays engine shutdown following retransfer to primary/normal source to permit generator to run unloaded for cooldown period.
- f. In-Phase Monitor (Open Transition Transfer Switches): Monitors phase angle difference between sources for initiating in-phase transfer.
- g. Engine Exerciser: Provides programmable scheduled exercising of engine generator selectable with or without transfer to load; provides memory retention during power outage.
- 3. Status Indications:
  - a. Connected to alternate/emergency source.
  - b. Connected to primary/normal source.
  - c. Alternate/emergency source available.
- 4. Automatic Sequence of Operations:
  - a. Upon failure of primary/normal source for a programmable time period (engine generator start time delay), initiate starting of engine generator where applicable.
  - b. When alternate/emergency source is available, transfer load to alternate/emergency source after programmable time delay.
  - c. When primary/normal source has been restored, retransfer to primary/normal source after a programmable time delay. Bypass time delay if alternate/emergency source fails and primary/normal source is available.
  - d. Where applicable, initiate shutdown of engine generator after programmable engine cooldown time delay.
- N. Service Entrance Rated Transfer Switches:
  - 1. Furnished with integral disconnecting and overcurrent protective device on the primary/normal source and with ground-fault protection where indicated.
  - 2. Listed and labeled as suitable for use as service equipment according to UL 869A.
- O. Bypass/Isolation Transfer Switches:
  - 1. Description: Factory-assembled units consisting of interconnected transfer switch and bypass/isolation switch that permits manual bypass and isolation of the transfer switch with connection of the load to either source.
  - 2. Bypass/Isolation Switch Type: Provide overlapping (make-before-break) switches with no interruption of power to load. Load break (break-before-make) switches that interrupt power to load are not acceptable.
  - 3. Bypass/Isolation Operation:
    - a. Operable from exterior of enclosure.
    - b. Normal Mode: Provides for normal operation of transfer switch.
    - c. Test Mode: Provides for operational testing of bypassed transfer switch without affecting power to load.
    - d. Isolate Mode: Provides for complete isolation of transfer switch from all power sources, permitting removal from unit.

## **PART 3 EXECUTION**

### **3.01 INSTALLATION**

- A. Perform work in accordance with NECA 1 (general workmanship).
- B. Install products in accordance with manufacturer's instructions.
- C. Arrange equipment to provide minimum clearances and required maintenance access.
- D. Provide required support and attachment in accordance with Section 26 0529.
- E. Install transfer switches plumb and level.
- F. Unless otherwise indicated, mount floor-mounted transfer switches on properly sized 3 inch high concrete pad constructed in accordance with Section 03 3000.
- G. Provide grounding and bonding in accordance with Section 26 0526.
- H. Identify transfer switches and associated system wiring in accordance with Section 26 0553.

### **3.02 FIELD QUALITY CONTROL**

- A. Provide services of a manufacturer's authorized representative to observe installation and assist in inspection and testing. Include manufacturer's detailed testing procedures and field reports with submittals.
- B. Prepare and start system in accordance with manufacturer's instructions.
- C. Automatic Transfer Switches:
  - 1. Inspect and test in accordance with NETA ATS, except Section 4.
  - 2. Perform inspections and tests listed in NETA ATS, Section 7.22.3. The insulation-resistance tests listed as optional are not required.
- D. Correct defective work, adjust for proper operation, and retest until entire system complies with contract documents.

### **3.03 MAINTENANCE**

- A. Provide to Owner a proposal as an alternate to the base bid, a separate maintenance contract for the service and maintenance of transfer switches for two years from date of Substantial Completion; Include a complete description of preventive maintenance, systematic examination, adjustment, inspection, and testing, with a detailed schedule.

**END OF SECTION**

**SECTION 26 4300**  
**SURGE PROTECTIVE DEVICES**

**PART 1 GENERAL**

**1.01 SECTION INCLUDES**

- A. Surge protective devices for service entrance locations.

**1.02 REFERENCE STANDARDS**

- A. NECA 1 - Standard for Good Workmanship in Electrical Construction; 2015.
- B. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- C. UL 1449 - Standard for Surge Protective Devices; Current Edition, Including All Revisions.

**1.03 SUBMITTALS**

- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Include detailed component information, voltage, surge current ratings, repetitive surge current capacity, voltage protection rating (VPR) for all protection modes, maximum continuous operating voltage (MCOV), nominal discharge current (I-n), short circuit current rating (SCCR), connection means including any required external overcurrent protection, enclosure ratings, outline and support point dimensions, weight, service condition requirements, and installed features.

**1.04 QUALITY ASSURANCE**

- A. Conform to requirements of NFPA 70.

**PART 2 PRODUCTS**

**2.01 SURGE PROTECTIVE DEVICES - GENERAL REQUIREMENTS**

- A. Description: Factory-assembled surge protective devices (SPDs) for 60 Hz service; listed, classified, and labeled as suitable for the purpose intended; system voltage as indicated on the drawings.
- B. Equipment Containing Factory-installed, Internally Mounted SPDs: Listed and labeled as a complete assembly including SPD.

**2.02 SURGE PROTECTIVE DEVICES FOR SERVICE ENTRANCE LOCATIONS**

- A. Unless otherwise indicated, provide field-installed, externally mounted or factory-installed, internally mounted SPDs.
- B. List and label as complying with UL 1449, Type 1 when connected on line side of service disconnect overcurrent device and Type 1 or 2 when connected on load side of service disconnect overcurrent device.
- C. Provide SPDs utilizing field-replaceable modular or non-modular protection circuits.
- D. Surge Current Rating: Not less than 120 kA per mode/240 kA per phase.
- E. UL 1449 Nominal Discharge Current (I-n): 20 kA.
- F. UL 1449 Short Circuit Current Rating (SCCR): Not less than the available fault current at the installed location as indicated on the drawings.
- G. Diagnostics:
  - 1. Protection Status Monitoring: Provide indicator lights to report the protection for each phase.
  - 2. Alarm Notification: Provide indicator light and audible alarm to report alarm condition. Provide button to manually silence audible alarm.

**PART 3 EXECUTION**

**3.01 INSTALLATION**

- A. Perform work in accordance with NECA 1 (general workmanship).

- B. Install products in accordance with manufacturer's instructions.
- C. Arrange equipment to provide minimum clearances in accordance with manufacturer's instructions and NFPA 70.
- D. Unless indicated otherwise, connect service entrance surge protective device on load side of service disconnect main overcurrent device.
- E. Provide conductors with minimum ampacity as indicated on the drawings, as required by NFPA 70, and not less than manufacturer's recommended minimum conductor size.
- F. Install conductors between SPD and equipment terminations as short and straight as possible, not exceeding manufacturer's recommended maximum conductor length. Breaker locations may be reasonably rearranged in order to provide leads as short and straight as possible. Twist conductors together to reduce inductance.
- G. Do not energize SPD until bonding of neutral and ground for service entrance and separately derived systems is complete in accordance with Section 26 0526 where applicable. Replace SPDs damaged by improper or missing neutral-ground bond.

**END OF SECTION**

**SECTION 26 5100  
INTERIOR LIGHTING**

**PART 1 GENERAL**

**1.01 SECTION INCLUDES**

- A. Interior luminaires.
- B. Emergency lighting units.
- C. Exit signs.

**1.02 ADMINISTRATIVE REQUIREMENTS**

- A. Coordination:
  - 1. Coordinate the installation of luminaires with mounting surfaces installed under other sections or by others. Coordinate the work with placement of supports, anchors, etc. required for mounting. Coordinate compatibility of luminaires and associated trims with mounting surfaces at installed locations.
  - 2. Coordinate the placement of luminaires with structural members, ductwork, piping, equipment, diffusers, fire suppression system components, and other potential conflicts installed under other sections or by others.
  - 3. Coordinate the placement of exit signs with furniture, equipment, signage or other potential obstructions to visibility installed under other sections or by others.
  - 4. Notify Architect of any conflicts or deviations from the contract documents to obtain direction prior to proceeding with work.

**1.03 SUBMITTALS**

- A. Product Data: Provide manufacturer's standard catalog pages and data sheets including detailed information on luminaire construction, dimensions, ratings, finishes, mounting requirements, listings, service conditions, photometric performance, installed accessories, and ceiling compatibility; include model number nomenclature clearly marked with all proposed features.
  - 1. LED Luminaires:
    - a. Include estimated useful life, calculated based on IES LM-80 test data.

**1.04 QUALITY ASSURANCE**

- A. Conform to requirements of NFPA 70.

**1.05 DELIVERY, STORAGE, AND PROTECTION**

- A. Receive, handle, and store products according to NECA/IESNA 500 (commercial lighting), NECA/IESNA 502 (industrial lighting), and manufacturer's written instructions.
- B. Keep products in original manufacturer's packaging and protect from damage until ready for installation.

**1.06 FIELD CONDITIONS**

- A. Maintain field conditions within manufacturer's required service conditions during and after installation.

**PART 2 PRODUCTS**

**2.01 LUMINAIRE TYPES**

- A. Furnish products as indicated in luminaire schedule included on the drawings.

**2.02 LUMINAIRES**

- A. Provide products that comply with requirements of NFPA 70.
- B. Provide products that are listed and labeled as complying with UL 1598, where applicable.
- C. Provide products listed, classified, and labeled as suitable for the purpose intended.

- D. Unless otherwise indicated, provide complete luminaires including lamp(s) and all sockets, ballasts, reflectors, lenses, housings and other components required to position, energize and protect the lamp and distribute the light.
- E. Unless specifically indicated to be excluded, provide all required conduit, boxes, wiring, connectors, hardware, supports, trims, accessories, etc. as necessary for a complete operating system.
- F. Provide products suitable to withstand normal handling, installation, and service without any damage, distortion, corrosion, fading, discoloring, etc.
- G. Recessed Luminaires:
  - 1. Ceiling Compatibility: Comply with NEMA LE 4.
  - 2. Luminaires Recessed in Insulated Ceilings: Listed and labeled as IC-rated, suitable for direct contact with insulation and combustible materials.
  - 3. Luminaires Recessed in Sloped Ceilings: Provide suitable sloped ceiling adapters.
- H. LED Luminaires:
  - 1. Components: UL 8750 recognized or listed as applicable.
  - 2. Tested in accordance with IES LM-79 and IES LM-80.
  - 3. LED Estimated Useful Life: Minimum of 50,000 hours at 70 percent lumen maintenance, calculated based on IES LM-80 test data.
- I. LED Tape Lighting Systems: Provide all power supplies, drivers, cables, connectors, channels, covers, mounting accessories, and interfaces as necessary to complete installation.
  - 1. LED Tape - General Requirements:
    - a. Listed.
    - b. Designed for field cutting in accordance with listing.
    - c. Wet Location Applications: IEC 60529, IP 68 (waterproof) rated.
- J. Track Lighting Systems: Provide track compatible with specified track heads, with all connectors, power feed fittings, dead ends, hangers and canopies as necessary to complete installation.
- K. Luminaires Mounted in Continuous Rows: Provide quantity of units required for length indicated, with all accessories required for joining and aligning.

### **2.03 EMERGENCY LIGHTING UNITS**

- A. Description: Emergency lighting units complying with NFPA 101 and all applicable state and local codes, and listed and labeled as complying with UL 924.
- B. Operation: Upon interruption of normal power source or brownout condition exceeding 20 percent voltage drop from nominal, solid-state control automatically switches connected lamps to integral battery power for minimum of 90 minutes of rated emergency illumination, and automatically recharges battery upon restoration of normal power source.
- C. Battery:
  - 1. Sealed maintenance-free lead calcium unless otherwise indicated.
  - 2. Size battery to supply all connected lamps, including emergency remote heads where indicated.
- D. Diagnostics: Provide power status indicator light and accessible integral test switch to manually activate emergency operation.
- E. Provide low-voltage disconnect to prevent battery damage from deep discharge.

### **2.04 EXIT SIGNS**

- A. Description: Internally illuminated exit signs with LEDs unless otherwise indicated; complying with NFPA 101 and all applicable state and local codes, and listed and labeled as complying with UL 924.
  - 1. Number of Faces: Single or double as indicated or as required for the installed location.
  - 2. Directional Arrows: As indicated or as required for the installed location.



## **PART 3 EXECUTION**

### **3.01 INSTALLATION**

- A. Perform work in accordance with NECA 1 (general workmanship).
- B. Install products in accordance with manufacturer's instructions.
- C. Install luminaires securely, in a neat and workmanlike manner, as specified in NECA 500 (commercial lighting) and NECA 502 (industrial lighting).
- D. Install luminaires plumb and square and aligned with building lines and with adjacent luminaires.
- E. Suspended Ceiling Mounted Luminaires:
  - 1. Do not use ceiling tiles to bear weight of luminaires.
  - 2. Do not use ceiling support system to bear weight of luminaires unless ceiling support system is certified as suitable to do so.
  - 3. Secure lay-in luminaires to ceiling support channels using listed safety clips at four corners.
  - 4. See appropriate Division 9 section where suspended grid ceiling is specified for additional requirements.
- F. Recessed Luminaires:
  - 1. Install trims tight to mounting surface with no visible light leakage.
  - 2. Non-IC Rated Luminaires: Maintain required separation from insulation and combustible materials according to listing.
  - 3. Luminaires Recessed in Fire-Rated Ceilings: Install using accessories and firestopping materials to meet regulatory requirements for fire rating.
- G. Suspended Luminaires:
  - 1. Unless otherwise indicated, specified mounting heights are to bottom of luminaire.
  - 2. Install using the suspension method indicated, with support lengths and accessories as required for specified mounting height.
  - 3. Provide minimum of two supports for each luminaire equal to or exceeding 4 feet nominal length, with no more than 4 feet between supports.
  - 4. Install canopies tight to mounting surface.
  - 5. Unless otherwise indicated, support pendants from swivel hangers.
- H. Wall-Mounted Luminaires: Unless otherwise indicated, specified mounting heights are to center of luminaire.
- I. Install accessories furnished with each luminaire.
- J. Bond products and metal accessories to branch circuit equipment grounding conductor.
- K. Emergency Lighting Units:
  - 1. Unless otherwise indicated, connect unit to unswitched power from same circuit feeding normal lighting in same room or area. Bypass local switches, contactors, or other lighting controls.
- L. Exit Signs:
  - 1. Unless otherwise indicated, connect unit to unswitched power from same circuit feeding normal lighting in same room or area. Bypass local switches, contactors, or other lighting controls.
- M. Install lamps in each luminaire.

### **3.02 FIELD QUALITY CONTROL**

- A. Inspect each product for damage and defects.
- B. Operate each luminaire after installation and connection to verify proper operation.
- C. Test self-powered exit signs, emergency lighting units, and fluorescent emergency power supply units to verify proper operation upon loss of normal power supply.

- D. Correct wiring deficiencies and repair or replace damaged or defective products. Repair or replace excessively noisy ballasts as determined by Architect.

**3.03 ADJUSTING**

- A. Aim and position adjustable luminaires to achieve desired illumination as indicated or as directed by Architect. Secure locking fittings in place.
- B. Aim and position adjustable emergency lighting unit lamps to achieve optimum illumination of egress path as required or as directed by Architect or authority having jurisdiction.
- C. Exit Signs with Field-Selectable Directional Arrows: Set as indicated or as required to properly designate egress path as directed by Architect or authority having jurisdiction.

**3.04 CLEANING**

- A. Clean surfaces according to NECA 500 (commercial lighting), NECA 502 (industrial lighting), and manufacturer's instructions to remove dirt, fingerprints, paint, or other foreign material and restore finishes to match original factory finish.

**3.05 CLOSEOUT ACTIVITIES**

- A. Demonstration: Demonstrate proper operation of luminaires to Architect, and correct deficiencies or make adjustments as directed.

**END OF SECTION**

**SECTION 26 5600  
EXTERIOR LIGHTING**

**PART 1 GENERAL**

**1.01 SECTION INCLUDES**

- A. Exterior luminaires.

**1.02 SUBMITTALS**

- A. Product Data: Provide manufacturer's standard catalog pages and data sheets including detailed information on luminaire construction, dimensions, ratings, finishes, mounting requirements, listings, service conditions, photometric performance, weight, effective projected area (EPA), and installed accessories; include model number nomenclature clearly marked with all proposed features.

**1.03 QUALITY ASSURANCE**

- A. Conform to requirements of NFPA 70.

**1.04 DELIVERY, STORAGE, AND HANDLING**

- A. Receive, handle, and store products according to NECA/IESNA 501 and manufacturer's written instructions.
- B. Keep products in original manufacturer's packaging and protect from damage until ready for installation.

**PART 2 PRODUCTS**

**2.01 LUMINAIRE TYPES**

- A. Furnish products as indicated in luminaire schedule included on the drawings.

**2.02 LUMINAIRES**

- A. Provide products that comply with requirements of NFPA 70.
- B. Provide products that are listed and labeled as complying with UL 1598, where applicable.
- C. Provide products listed, classified, and labeled as suitable for the purpose intended.
- D. Unless otherwise indicated, provide complete luminaires including lamp(s) and all sockets, ballasts, reflectors, lenses, housings and other components required to position, energize and protect the lamp and distribute the light.
- E. Unless specifically indicated to be excluded, provide all required conduit, boxes, wiring, connectors, hardware, poles, foundations, supports, trims, accessories, etc. as necessary for a complete operating system.
- F. Provide products suitable to withstand normal handling, installation, and service without any damage, distortion, corrosion, fading, discoloring, etc.

**PART 3 EXECUTION**

**3.01 EXAMINATION**

- A. Verify that field measurements are as indicated.
- B. Verify that outlet boxes are installed in proper locations and at proper mounting heights and are properly sized to accommodate conductors in accordance with NFPA 70.
- C. Verify that suitable support frames are installed where required.
- D. Verify that branch circuit wiring installation is completed, tested, and ready for connection to luminaires.
- E. Verify that conditions are satisfactory for installation prior to starting work.

**3.02 PREPARATION**

- A. Provide extension rings to bring outlet boxes flush with finished surface.
- B. Clean dirt, debris, plaster, and other foreign materials from outlet boxes.

### **3.03 INSTALLATION**

- A. Coordinate locations of outlet boxes provided under Section 26 0533.16 as required for installation of luminaires provided under this section.
- B. Perform work in accordance with NECA 1 (general workmanship).
- C. Install products in accordance with manufacturer's instructions.
- D. Install luminaires in accordance with NECA/IESNA 501.
- E. Install luminaires plumb and square and aligned with building lines and with adjacent luminaires.
- F. Recessed Luminaires:
  - 1. Install trims tight to mounting surface with no visible light leakage.
  - 2. Non-IC Rated Luminaires: Maintain required separation from insulation and combustible materials according to listing.
  - 3. Luminaires Recessed in Fire-Rated Ceilings: Install using accessories and firestopping materials to meet regulatory requirements for fire rating.
- G. Suspended Luminaires:
  - 1. Unless otherwise indicated, specified mounting heights are to bottom of luminaire.
  - 2. Install using the suspension method indicated, with support lengths and accessories as required for specified mounting height.
  - 3. Provide minimum of two supports for each luminaire equal to or exceeding 4 feet in length, with no more than 4 feet between supports.
  - 4. Install canopies tight to mounting surface.
- H. Wall-Mounted Luminaires: Unless otherwise indicated, specified mounting heights are to center of luminaire.
- I. Install accessories furnished with each luminaire.
- J. Bond products and metal accessories to branch circuit equipment grounding conductor.
- K. Install lamps in each luminaire.

### **3.04 FIELD QUALITY CONTROL**

- A. Inspect each product for damage and defects.
- B. Operate each luminaire after installation and connection to verify proper operation.
- C. Correct wiring deficiencies and repair or replace damaged or defective products. Repair or replace excessively noisy ballasts as determined by Architect.

### **3.05 ADJUSTING**

- A. Aim and position adjustable luminaires to achieve desired illumination as indicated or as directed by Architect. Secure locking fittings in place.

**END OF SECTION**